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A DIAGNOSIS OF THE ACHIEVEMENT OF A SAMPLE OF ALBERTA
GRADE EIGHT PUPILS IN SOLVING ARITHMETIC PROBLEMS

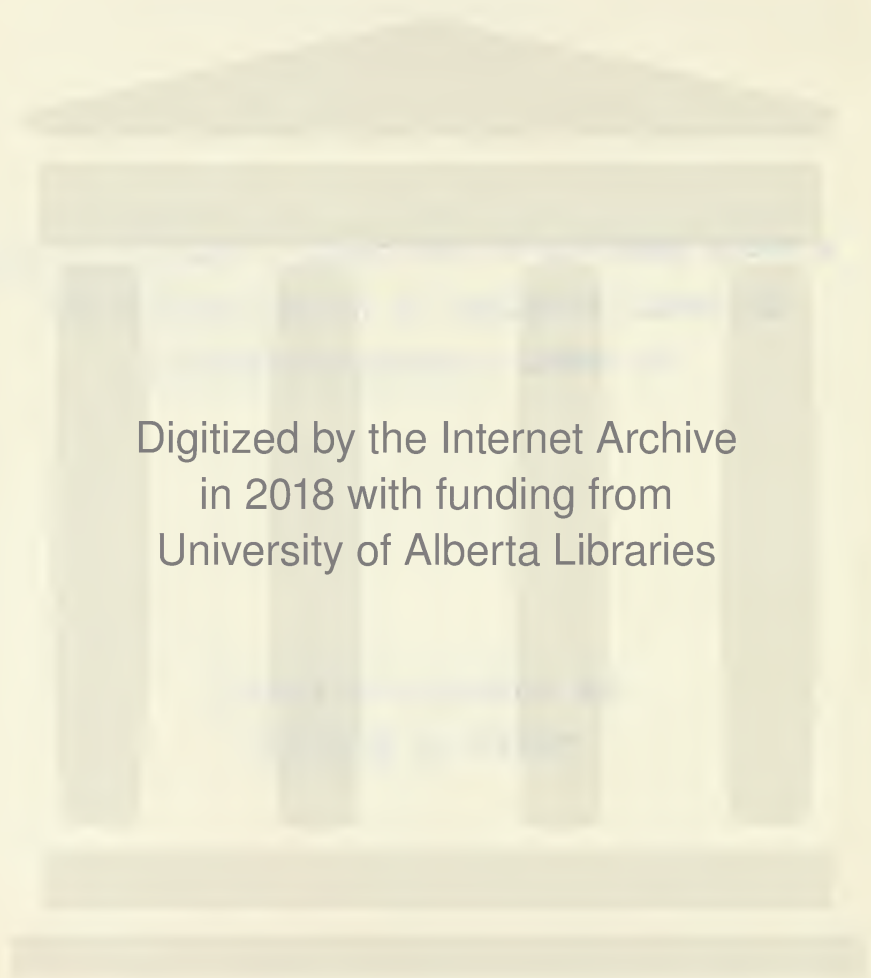
A THESIS SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES
IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR
THE DEGREE OF MASTER OF EDUCATION

THE UNIVERSITY OF ALBERTA
FACULTY OF EDUCATION

BY

OSCAR FADUM

SEPTEMBER, 1956



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The undersigned hereby certify that they have read and recommend to the School of Graduate Studies for acceptance, a thesis entitled, "A Diagnosis of the Achievement of a Sample of Alberta Grade Eight Pupils in Solving Arithmetic Problems," submitted by Oscar Fadum, B. Educ., in partial fulfilment of the requirements for the degree of Master of Education.

Professor

Professor

Professor

September 27, 1956.

ACKNOWLEDGEMENTS

The writer is indebted to many people for assistance and guidance in this project. The Alberta Committee on Educational Research made available the completed tests from which the data were gathered. The testing program was carried out under the direction of members of the Faculty of Education; the papers were machine scored by courtesy of the Department of Education, and clerical workers in the Faculty of Education had compiled the raw data.

Members of the staff of the Education Library gave their full co-operation. Professors and fellow graduate students offered many suggestions and constructive criticisms at seminars under the leadership of Dr. Walker.

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To all of these, the writer offers his sincere thanks.

SYNOPSIS

This thesis, "A Diagnosis of the Achievement of a Sample of Alberta Grade Eight Pupils in Solving Arithmetic Problems", is the report of an attempt to analyze achievement and weaknesses in problem solving on a standardized arithmetic test. Four hundred answer papers written by Alberta grade eight pupils from various parts of the province and from different types of schools were studied with the object of finding whether these students solve all types of problems with equal facility; whether their difficulties may be diagnosed for remedial purposes; whether there is equal proficiency among pupils from urban, town, graded rural, and ungraded rural schools in solving different types of problems, and whether grade eight boys and girls are equally adept at solving problems of different types.

When the statistics of the study were compiled, it was found that our grade eight pupils are much more proficient in solving problems of one type than another.

Pupils' weaknesses were diagnosed and classified, and remedial and preventive teaching could have been implemented after the test results were studied.

When the results of the four types of schools were

compared, it was found that in the over-all test, the rank order of achievement was urban, graded rural, town, and ungraded rural. However, this order did not prevail in all types of problems. With the exception of ungraded rural schools, each type of school excelled in some class of problems.

Although boys generally showed a slight superiority over girls in solving problems, this difference was often insignificant, and in some cases girls achieved better than boys. This was particularly true in ungraded rural schools, and in certain types of problems, girls excelled in other schools as well.

On the basis of these findings, certain recommendations have been made, which, if adopted, may help to equalize educational opportunities for pupils in Alberta schools and improve achievement in solving problems in arithmetic.

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CHAPTER I

THE PURPOSE OF THE STUDY

Arithmetic is a social subject. In almost everything we do, whether as individuals or in interaction with others, we use numbers. It is therefore of great importance that we gain some insight and develop some facility in mathematics. If we are to become efficient in the use of numbers, we must find them meaningful, and meaningful arithmetic is found in problems. For that reason, it seems important that we learn how well our pupils are able to deal with problems in numbers.

The primary purpose of this study is to diagnose both the achievement and the shortcomings of our grade eight pupils in solving arithmetical problems. A secondary purpose is to make certain recommendations to teachers of arithmetic in order to attempt to improve instruction in those fields which are least effectively handled by our pupils. Since grade eight is the last grade in which mathematics instruction is primarily in the field of arithmetic, this study deals exclusively with pupils from that grade.

More specifically, it is the aim of this study to determine the answers to questions such as the following:

1. Do the grade eight pupils in Alberta solve all types of problems with equal facility or difficulty, or do

- they achieve better in some types than in others?
2. Can their shortcomings be diagnosed so that preventive teaching and remedial work may be implemented and thus help our pupils to become more proficient in solving problems?
 3. Is there equal proficiency in all phases of problem solving among the grade eight pupils of urban, town, graded rural and ungraded rural schools in Alberta?
 4. Is there equality in proficiency in solving all types of problems between grade eight girls and boys in Alberta schools?

I. THE DESCRIPTIVE METHOD -- ANALYSIS

The purpose of analytical description in research is said by Good and Scates to be "to uncover what lies beneath the surface."¹

Under the heading Meaning of Analysis, the same authors continue:

All who teach covet a finer knowledge of the way in which the birth of an idea takes place. We know less of mental growth than of physical. Is learning to be viewed simply as a process? Or is it a matter of adding on one building block after another? Does an area of expanding comprehension represent just more blocks? Or a different kind of structural

¹Carter V. Good and Douglas E. Scates, Methods of Research (New York: Appleton-Century-Crofts, Inc., 1954), p. 277.

relation among them? Or something that cannot be thought of in terms of units at all? The same questions arise when we think of ability in cross section.²

Since the questions posed by these authors are closely related to the purposes of the present study, analytical research seems to be logical means by which to attempt to find the answers to the questions asked by the present investigator.

II. TIMELINESS AND IMPORTANCE OF THE STUDY

Statistical studies have recently been conducted in Alberta in some of the major fields of learning, notably the Carmichael -- Rees survey of reading achievement, the Reid -- Conquest survey of language achievement, and the Pritchard -- Climenhaga survey of arithmetical achievement. Further reference will be made to the last-mentioned study in the section devoted to related literature. Suffice it here to say that the Pritchard -- Climenhaga study is a normative survey of arithmetical achievement of Alberta grade five and grade eight pupils, including achievement in problem solving. While norms are compared between Alberta pupils and those of other regions, that study is limited to an over-all view of such proficiency. It is important also

²Ibid., p. 278.

for purposes of preventive teaching and remedial work that inefficiency be analyzed, so that difficulties may be pinpointed. That is what this study purports to do. It is hoped that the answers found to the questions listed earlier in this chapter may serve as a guide to teachers in the field, and that the conclusions may lead to further investigations.

The writer acknowledges that this study has definite limitations. Some of these will be dealt with more fully in a description of the testing instrument in Chapter IV. At this time it will be enough to state that because of certain limitations of the testing instrument for diagnostic purposes, the percentages shown in the treatment of the data are relative only, and not an accurate statistical representation of pupils' errors. The reason for this will be made clear later. The investigator feels that this limitation does not lessen the value of the study appreciably.

III. PREVIEW OF THE THESIS

Chapter II of this thesis contains a survey of literature related to problem solving in arithmetic. It reviews both general discussions of problem solving and previous studies conducted in this field. Chapter III explains the sampling technique and the experimental design of this study, including the gathering of data and the plan for reporting them. Chapter IV describes and evaluates Part III -- Problem

Solving of the Iowa Every-Pupil Test of Basic Arithmetic Skills as a measuring instrument. Chapter V presents the data on achievement of Alberta grade eight pupils on the problems in this test, while Chapter VI reports on difficulties encountered by the same pupils. Chapter VII summarizes the findings or conclusions of this study and makes recommendations to teachers of arithmetic in Alberta schools. A bibliography lists references used by the writer in compiling data and preparing this report. Finally, an appendix gives an analysis of the portion of the testing instrument used in this study.

CHAPTER II

RELATED LITERATURE

The literature related to this study may be divided roughly into two types: general texts and articles dealing with problem solving in arithmetic, and reports of other studies or investigations made in this field. Only such literature as was directly useful to the writer in his study has been included.

I. TEXTS AND ARTICLES ON PROBLEM SOLVING

J.F. Weaver has this to say about the relationship between computation and problem solving:

It is quite possible that a person may possess considerable skill in arithmetic computation but have little or no understanding of why he does things in a manner which has become well habituated.

It is equally possible that a person may have a thorough understanding of the mathematical bases for the algorithms which he uses but operate at a relatively low level of computational efficiency.¹

This then would suggest that in analyzing weaknesses in problem solving, the first classification might well be between computational inefficiency (which would not be peculiar to problem solving, but would be prevalent in all

¹J.F. Weaver, "Some Misunderstanding About Meaning in Arithmetic," Elementary School Journal, 51: 35 - 41.

phases of a weak pupil's work with numbers), and actual difficulties with the processes of solution of problems, which is what this study in part purports to do. Once computational difficulties have been dealt with, the remainder of this study will report on weaknesses which are not a direct result of inefficiency in computation, but rather of inefficiency in other areas which lead to incorrect solutions.

Wilson,² reporting in the Encyclopedia of Educational Research, indicates that if arithmetic is to be of value, it must be useful socially. He makes references to studies by Traniello, Louth, Sala, and Dorothy Wilson which point out that various devices for gaining skill in denominate numbers have little or no value. He lists:

...committing to memory of tables; addition subtraction, multiplication, and division of compound numbers; reductions ascending and descending.³

He goes on to say that:

... pupils tend not to reason when they attempt to solve verbal problems of the usual textbook types.⁴

He further quotes Hyde and Clapp as reporting that:

If the problem could be visualized it became almost as easy as if it has occurred within the

²G.M. Wilson, "Arithmetic," Encyclopedia of Educational Research, Revised Edition, 1950. (New York: MacMillan Company, 1950.)

³Ibid., p. 46.

⁴Ibid., p. 54.

child's experience.⁵

The writer suggests that the remedy is better problems and better teaching. He offers evidence to indicate that reading verbal problems requires both special reading skills and a knowledge of the type of vocabulary used in problem statements. He stresses that understanding the problem must be superior to getting correct solutions.

Brueckner and Grossnickle⁶ in a chapter on The Scope of Problem Solving in Arithmetic corroborate this. They compare the outmoded method of problem solving which was mental gymnastics of a mechanical nature with the present idea of developing quantitative thinking to gain insight into problems.

These authors deal particularly with reading skills which are related to quantitative thinking:

The ability to read quantitative materials of many different kinds with understanding and for a wide variety of purposes is fundamental to success in arithmetic. It is the basis of much of our quantitative thinking. The ability to read explanations of number processes, problems, graphs, instruments of measurements, and diagrams is quite different from the ability to read literary materials such as stories or newspaper clippings.⁷

⁵Ibid.

⁶L.J. Brueckner and F.E. Grossnickle, Making Arithmetic Meaningful, (Philadelphia: The John C. Winston Company, 1953.) Chapter 13, pp. 491 - 532.

⁷Ibid., p. 498.

They recommend the use of survey tests to discover weaknesses in verbal problems explaining that through such testing it is possible to make an evaluation of a pupil's knowledge of quantitative vocabulary and social applications of arithmetic as well as to appraise his ability to interpret graphs and tables. This, in part, is what the present study proposes to do on a group basis.

Glennon and Hunnicutt reporting in "What Does Research Say About Arithmetic?" stress the importance of meanings in arithmetic by quoting Brownell's summary:

1. Arithmetic can function in intelligent living only when it is understood. ... It is a fallacy to classify arithmetic as a skill or a drill or a tool subject. In practical living we must be intelligent in quantitative situations. For many years we have been told that skills can be used intelligently only when they have been acquired intelligently; hence the importance of meanings in arithmetic.

Meanings facilitate learning. ... Through meanings we secure insights and note relationships which, without meanings, we should not be likely to hit upon. The insights in turn enable us to foresee connections and to tie together various aspects of the learning task which, without understanding, would have to be mastered separately, one at a time.⁸

II. INVESTIGATIONS IN PROBLEM SOLVING

Brueckner and Grossnickle give the following summary of studies made by Treacy and Hansen at the University of

⁸V.J. Glennon and C.W. Hunnicutt, What Does Research Say About Arithmetic?, Association for Supervision and Curriculum, A Department of the National Educations Association, Washington, D.C., 1952, p. 14.

Minnesota:

1. In such psychological factors as general mental ability, delayed and immediate memory, language level, and general reading ability, the differences between good and poor achievers in problem solving are highly significant in favor of the good achievers, that is, the scores for good achievers excel those of poor achievers.

2. The differences in skill in fundamental operations and ability to estimate answers also are highly significant in favor of the good achiever.

3. The differences in four basic reading skills peculiar to arithmetic as a special field ... and in range of information about arithmetic also are highly significant in favor of the good achievers.

4. The differences between good and poor achievers in problem solving in range of general information and in the four general reading skills measured by the four Gates Silent Reading Tests are shown not to be significant. This conclusion is in sharp contrast to the third conclusion stated above.⁹

This again would seem to indicate that for purposes of problem solving, not only is general ability to read essential, but it is also necessary that the pupil have special reading skills in interpreting quantitative expression.

Gibb¹⁰ reports in The Journal of Educational Research an investigation made by Johnson to determine whether improvement in specific mathematical vocabulary helps in solving problems in which this vocabulary is used. In working with

⁹Brueckner and Grossnickle, op. cit., pp. 513 - 514.

¹⁰Glenadine Gibb, "A Review of a Decade of Experimental Studies Which Compared Methods of Teaching Arithmetic." Journal of Educational Research, 46: 603 - 608.

a group of 898 grade seven pupils equated as to chronological and mental age, reading ability, knowledge of arithmetic vocabulary, abilities, nationality, and occupation of the father, he reached the following conclusions:

1. There was significant growth in knowledge where the specific terms were used.
2. There was no general improvement in arithmetic learnings.
3. There was no evidence of transfer of learning.

Johnson¹¹ later tested to find reasons for difficulty in problem solving, giving two problem-tests, one with number and the other without. He reached the conclusions that knowledge of vocabulary is the main factor in problem-solving ability; the second factor being ability to reason. There is also inconclusive evidence that problem-solving ability may be influenced by memory.

In 1932, Tanner¹² tested 432 grade five pupils from Edmonton schools, comparing their achievement in problem solving in relation to I.Q., sex and age. He found that I.Q. is the most important factor in determining ability in solv-

¹¹J.T. Johnson, "On the Nature of Problem-Solving in Arithmetic," Journal of Educational Research, 43: 110 - 115.

¹²H.E. Tanner, The Relation Between Problem Solving Ability in Grade V Arithmetic and Each of the Variables: Sex, Chronological Age and Mental Age, Unpublished Graduate Thesis, University of Alberta, 1932.

ing problems, that age, while significant, is not so important as might be expected, and that boys are generally superior to girls in achievement in this field.

Swift¹³ in his Investigation of Abilities of Grade IV, V and VI Pupils in Solving and Analyzing Problems in Arithmetic, came up with conclusions which seem to contradict most of the findings of other investigators. He found that pupils' abilities to understand problems lag far behind their abilities to get correct solutions for them, and that ability to analyze a problem is not essential to efficiency in its solution. He also found that ability to explain principles involved in a problem does not greatly increase efficiency in its solution, nor does inability to explain imply failure on a problem.

On the other hand, Hall¹⁴ in a diagnostic study of the difficulties encountered in the LaZerte Survey Tests twelve years after Swift's study, concluded that denominate relationships can be effectively learned only through activity, that pupils with difficulties lack ability to visualize the

¹³W.H. Swift, An Investigation of Abilities of Grade IV, V and VI Pupils in Solving and Analyzing Problems in Arithmetic. Unpublished Graduate Thesis, University of Alberta, 1930.

¹⁴L.G. Hall, A Diagnosis of Difficulties Encountered in the LaZerte Survey Tests in Arithmetic. Unpublished Graduate Thesis, University of Alberta, 1942.

experience, and that learning arithmetic vocabulary is important.

LaZerte in his series of studies in problem solving reached conclusions very similar to those of Swift. He says:

1. The ability of school children fully to understand problems lags far behind their ability to get correct answers.

2. The ability to analyze a problem is not essential to efficiency in problem-solving. The solution depends rather on certain habits of response which do not require analysis.¹⁵

Nevertheless, at the end of his investigations, LaZerte listed the following findings:

Pupils are handicapped in problem-solving if they are deficient in reading ability. ... The special vocabulary of arithmetic, its technical terms, its abbreviations, and its conventions must be understood. ... Other things being equal, the pupil for whom the problem is full of meaning is aided in estimating in advance the result of operations to be performed and in approximating to results. ... Pupils are aided in problem-solving by training in analysis.¹⁶

More recent studies in arithmetic have been carried out by investigators sponsored by the Committee on Educational Research, Faculty of Education, University of Alberta.

¹⁵M.E. LaZerte, The Development of Problem-Solving Ability in Arithmetic, (Toronto: Clarke, Irving and Company Limited, 1933.) p. 57.

¹⁶Ibid., pp. 123 - 126.

Climenhaga¹⁷ and Pritchard¹⁸ carried out parallel investigations of arithmetic achievement of grade eight and grade five pupils respectively in Alberta schools, while Peta¹⁹ evaluated arithmetical competence of junior high school students in the city of Lethbridge.

These were normative surveys rather than diagnostic, although Peta also diagnosed areas of strength and weaknesses. A comparison of their findings is interesting and useful in forming hypotheses for the present study.

Both Pritchard and Climenhaga found a tendency for boys to be superior to girls in arithmetic. Peta did not differentiate between the sexes. Again the two aforementioned investigators found that Alberta students compared more favorably with the test norms in the part dealing with problem solving, while they suffered slightly by comparison on the other part of the test. They found urban pupils superior to those from town and rural schools. Peta's study was limited to city pupils, which may explain why the subjects he

¹⁷Clarence E. Climenhaga, "A Survey of Arithmetical Achievement of Grade Eight Pupils in Alberta Schools," The Alberta Journal of Educational Research, December, 1955.

¹⁸Ralph O. Pritchard, "A Survey of the Arithmetical Achievement of Grade Five Pupils in Alberta Schools," The Alberta Journal of Educational Research, March, 1956.

¹⁹Stephen Benjamin Peta, "An Evaluation of Arithmetical Competence in the Junior High Schools of Lethbridge," The Alberta Journal of Educational Research, June, 1956.

tested compared favorably with the standardization groups. All of these investigators found weaknesses in arithmetical achievement, which would confirm the need for the present investigation.

Nearly all the evidence encountered in the survey of literature outlined above seems to point at the causes of difficulties listed in the problem of this study. For the purposes of this investigation, therefore, the hypothesis will be that pupils' weaknesses in problem solving may be so categorized.

CHAPTER III

THE EXPERIMENTAL DESIGN

Since a normative survey had already been conducted by Climenhaga¹ using one thousand grade eight pupils randomly chosen from four types of Alberta schools, permission was obtained by the writer of this report from the committee sponsoring the study to analyze a subsample of four hundred answer sheets for purposes of diagnosing achievement and deficiencies in problem solving. This chapter will discuss the method of obtaining the subsample, and explain the procedure used in diagnosis, such as classifying difficulties, as well as treatment given the data in preparing it for this report.

I. SELECTION OF THE SAMPLE

The original sample of Alberta grade eight pupils used in Climenhaga's study consisted of 390 urban pupils, 251 from towns, 227 from graded rural schools, and 202 from ungraded rural schools. These 1070 pupils had been selected randomly in direct proportion to the grade eight school population in the four types of Alberta schools. Each pupil had been

¹Clarence E. Climenhaga, A Survey of Arithmetical Achievement of Grade Eight Pupils in Alberta Schools, Unpublished Master's Thesis, University of Alberta, 1955.

given a number on assembly sheets.

The same proportion was retained in the subsample of 400 used in this investigation. Thus the present sample consists of 145 urban pupils, 94 town pupils, 85 from graded rural schools, and 76 from ungraded rural schools. (Actually the number of pupils in each category becomes a mixed number, with the fractions totalling three pupils. These were arbitrarily assigned one to each of the three smallest groups.)

Since a number of the original 1070 had not actually written the test, and since the 400 pupils in the subsample were considered a minimum number for purposes of analysis, only those pupils for whom data could be obtained were made eligible for selection in the present study.

Slips containing numbers corresponding to the numbers assigned to pupils on the assembly sheets were prepared and thoroughly mixed in a container. The required quantity was drawn by lot, and the numbers so selected were recorded. The result of this procedure was a sample of 198 boys and 202 girls. The answer sheets completed by the pupils selected were then gathered from the file at the Faculty of Education.

Good and Scates have this to say about the method of selecting the sample outlined above:

The procedures commonly used to select random samples of human populations include: drawing by lot numbered slips of paper from a container,

capsules from a gold-fish bowl, or balls from an urn ²

Garrett also defends this method of choosing the sample. He says: "Randomness in a sample is assured when we draw similar and well shaken-up slips out of a hat"³

Further to confirm the validity of the subsample, a comparison was made between the mean scores on the problem solving part of the test in the original sample as reported by Climenhaga,⁴ with the mean scores on the subsample used in this investigation. This comparison is shown in Table I below:

TABLE I.

COMPARISON OF MEAN SCORES IN PROBLEM SOLVING OF THE ORIGINAL SAMPLE WITH THOSE OF THE SUBSAMPLE

Sample	N_1	M_1	SD_1	N_2	M_2	SD_2
Urban	380	17.71	4.10	145	17.63	3.82
Town	222	17.61	4.02	94	17.38	3.87
G.R.	213	17.68	4.24	85	17.60	4.16
U.R.	201	16.07	4.26	76	15.72	4.29

²Carter V. Good and Douglas E. Scates, Methods of Research, (New York: Appleton-Century-Crofts, Inc., 1954.) p. 601.

³Henry E. Garrett, Statistics in Psychology and Education, Fourth Edition, (New York: Longmans, Green and Co., 1953.) p. 202.

⁴Clarence E. Climenhaga, "A Survey of Arithmetical Achievement of Grade Eight Pupils in Alberta Schools," The Alberta Journal of Educational Research, December, 1955. p. 46.

Table I indicates a very slight difference in all pairs of mean scores. In every case the mean of the subsample is slightly lower than that in the original, but the order of achievement remains the same in both, i.e. Urban, Graded Rural, Town, and Ungraded Rural in that order.

The differences of the means were tested for significance in the following manner: The differences of the means were computed. The standard error of the difference was found by using the formula

$$SE_{DIFF_{SD}} = \sqrt{SE^2_{SD_1} + SE^2_{SD_2}} \quad \frac{DIFF_{SD}}{SE_{DIFF_{SD}}}$$

The critical ratio was found by the formula $CR = \frac{DIFF_{SD}}{SE_{DIFF_{SD}}}$

This critical ratio was then checked against Table D in Garrett⁵ for significance. The result of this test is shown in Table II below.

TABLE II.

SIGNIFICANCE OF DIFFERENCE OF MEAN SCORES ON ORIGINAL SAMPLE AND SUBSAMPLE

Sample	M_D	SE_D	CR	SIG.
Urban	.08	.38	.21	Nil
Town	.23	.48	.48	Nil
G.R.	.08	.54	.15	Nil
U.R.	.35	.57	.61	Nil

⁵Garrett, op. cit., p. 427.

Since, in every case, there was no significant difference in the mean scores, the null hypothesis was retained, and the writer feels that he has a valid sample with which to carry out his investigation.

II. EXPERIMENTAL DESIGN

Once the sample was chosen and the answer sheets gathered, every question on each pupil's answer sheet was checked and the solutions recorded to determine the frequency of each choice. Pupils were grouped according to the type of school attended, and according to sex. When the frequency of responses had been tabulated, the problems were classified according to the categories outlined below, and comparisons were made as to differential achievement and difficulties encountered by each group.

Achievement in each group of problems was handled first; then difficulties were diagnosed. Comparisons were made of problems omitted, difficulties in computation, reading, ability to apply denominate numbers, processes in problem solving, the use of per cent and fractions, ability to estimate answers, ability to visualize problems from drawings and diagrams, and the use of formulas. Some difficulty was experienced by the writer in classifying "N" answers. A detailed explanation of this type of response will be given in Chapter IV.

III. STATISTICAL PROCEDURES

In order to make comparisons statistically sound, percentages of responses over attempted solutions were computed for each group of pupils according to school attended and sex. For purposes of comparison, the significance of differences of percentages between the pairs of groups was computed according to the method recommended by Garrett.⁶ The chapters devoted to presentation of the data describe the findings of these computations.

⁶Garrett, op. cit., pp. 236 - 237.

CHAPTER IV

THE TESTING INSTRUMENT

This survey is based on Part III -- Problems of The Iowa Every-Pupil Tests of Basic Skills, New Edition, Test D: Basic Arithmetic Skills Form O, Advanced Battery, For Grades Five to Nine.¹ In the following pages, the part of the test used in this study will be referred to as "the problem test". The present chapter will give reasons for choosing this testing instrument and present an evaluation of its usefulness for diagnostic purposes.

One reason for this choice of testing instrument was the availability of materials from which the data could be processed. Reference has been made earlier in this report to a recent study by Climenhaga² in which the complete Iowa Test D in Arithmetic was used. The completed tests had been machine scored by the Faculty of Education, University of Alberta, and tabulation of data assembly sheets had been completed by hired clerical assistants. Using the same instrument, therefore, saved time, money and labor.

¹H.F. Spitzer and others, Iowa Every-Pupil Tests of Basic Skills, New Edition, Test D: Basic Arithmetic Skills, Advanced Battery, Grades 5-6-7-8-9, (Boston: Houghton Mifflin Company, 1943.)

²Clarence E. Climenhaga, A Survey of Arithmetical Achievement of Grade Eight Pupils in Alberta Schools, Unpublished Master's Thesis, University of Alberta, 1955.

A more important reason was its suitability for the purposes of this investigation. The test consists of 31 problems requiring for correct solutions a wide variety of mathematical skills which may be analyzed without too much difficulty. The authors of the test have this to say about interpretation of test results:

An analysis is given of the skills tested in Part I, since these are not clearly identified in many texts, but none is offered for Parts II and III. The teacher should have no difficulty in recognizing just what each of the items in these parts is intended to test.³

The writer found certain limitations in the use of the test for diagnostic purposes, but feels that these are offset by its many desirable features. The first of these limitations is the lack of an analysis by the authors, which necessitated a detailed study of the test. Such a study is not very difficult, since each choice on the answer sheet, with the exception of "N" answers, indicates a definite procedure followed by the pupil in his attempted solution. The multiple-choice type of response makes such a scrutiny of the test essential, since pupils are not required to write complete solutions to the problems. This analysis, which is recorded in the appendix of this report, also served to make

³Iowa Every-Pupil Tests of Basic Skills, New Edition, Examiner's Manual For Test D -- Advanced Basic Arithmetic Skills, Grades 5 - 9, (Boston: Houghton Mifflin Company, 1945.) p. 17.

the investigator thoroughly familiar with the testing instrument. Leroy H. Schnell, reviewing the test in Buros, feels that the Examiner's Manual should have included such classification. He says:

The analysis of all items of Part I of the tests should prove most helpful. ... Analysis of the skills involved in items of Parts II and III would prove as useful as this information for Part I.⁴

The "N" type of answer caused the writer some difficulty, as it is impossible to analyze the process followed by a pupil who arrives at this solution. This difficulty was made more acute by the fact that "N" answers were very popular with the pupils tested, even when they were incorrect choices. One of Buswell's findings in his recent study of patterns of thinking may account for so many responses of this type. He observes that:

... although there appears to be a considerable degree of uniformity in the sequence employed by a group of subjects in solving a simple problem, there is also a great deal of individual variation in patterns of solution ...⁵

The "N" response might include a multitude of patterns. Since it is possible for any of the weaknesses diagnosed in this to lead to such an answer, the "N" choices have been grouped

⁴Oscar Krisen Buros, (ed.) The Third Mental Measurements Yearbook, (New Brunswick, New Jersey: Rutgers University Press, 1949.) p. 423.

⁵Guy T. Buswell, Patterns Of Thinking In Solving Problems, (Los Angeles: University of California Press, 1956.) p. 89.

as a separate part of the analysis of difficulties.

Schnell in his review vigorously attacks the "N" type of answer:

Here a new feature, definitely open to challenge, is introduced. In 54 items, "N" is one of the four choices. Pupils are instructed to place an X in the box by the answer that agrees with theirs; but 'if none of the three answers given is like yours, place an X in the box in front of the N.' In approximately 20 per cent of these 54 items the correct response is "N". Hence a pupil actually may solve one of these problems incorrectly and still be awarded a score merely because his incorrect answer was different from the three incorrect answer choices! The procedure is educationally unsound, in addition to the fact that grade and age equivalents for Form O cannot be given credence.⁶

The writer of this report was not nearly so troubled about "N" responses which were correct as about "N" choices which were incorrect. At any rate, Miriam M. Bryan, reviewing the same test in a later edition of Buros, expresses an opinion which nullifies Schnell's condemnation of "N" responses by reporting:

An innovation in the machine scorable forms is the use in Parts II and III of the 'None' response, standing for 'None of the preceding answers is correct.' The validity of this type of response, when there is one indisputably correct answer to the question asked and the response accompanying the 'NONE' have been carefully constructed to cover the commonest errors, has been well established.⁷

⁶Buros, The Third Mental Measurement Yearbook, op. cit., pp. 423 - 424.

⁷Oscar K. Buros, (ed.) The Fourth Mental Measurements Yearbook, (Highland Park, New Jersey: The Gryphon Press, 1953.) pp. 40 - 41.

Still another difficulty encountered by the writer in using this testing instrument was the large number of responses omitted, presumably due in large measure to the fact that the Iowa Test has a time limit. Schonell⁸ in defining a diagnostic test explains that since its main object is to analyze rather than to assess, the speed factor should be ignored, and ample time provided for pupils to complete all they are able to do. Since, obviously, the Iowa test does not offer this feature, a statistical study has been made of the number of omissions, while other comparisons of difficulties encountered by the pupils are based on attempted solutions rather than on the possible number.

Despite these limitations of the testing instrument, there is ample support for its suitability. Gustav J. Froelich states that in his experience " ... the Iowa Every-Pupil Tests of Basic Skills are most valuable as diagnostic instruments."⁹ Anton Thompson agrees with this when he says: "Teachers who follow the authors' suggestions for analyzing the pupils' errors find the tests useful as diagnostic

⁸Fred J. Schonell, Diagnosis of Individual Difficulties in Arithmetic, (Toronto: Clarke, Irwin & Company Limited, 1948.)

⁹Buros, The Third Mental Measurements Yearbook, op. cit., p. 22.

instruments."¹⁰ Ralph C. Preston also reports that "all tests in these batteries lend themselves to diagnostic purposes more successfully than tests in most achievement batteries."¹¹ Climenhaga in his conclusions found that "for normal classroom use and individual diagnosis, it (the Iowa Test) appears quite reliable."¹²

Several reviewers have praise for the subject matter covered in the test as well. Thus, Frederick L. Ayer reports:

The arithmetic test is almost evenly divided among vocabulary and fundamental knowledge and includes distance judgment, time telling, and the understanding of the reasons behind basic computations, fundamental operations, and story problems. In general, the content is well presented and appears appropriate to grade levels.¹³

William A. Brownell, speaking of the problem test, has this to say:

The problems in Part III are also typical of curricular and measurement practice, though they are more 'practical' and are perhaps better stated than is the rule. The use of centers of interest for organizing groups of problems is to be commended. Isolated problems, however, still serve an important

¹⁰Buros, The Fourth Mental Measurements Yearbook, op. cit., p. 41.

¹¹Ibid., p. 23.

¹²Clarence E. Climenhaga, "A Survey of Arithmetical Achievement Of Grade Eight Pupils In Alberta Schools," The Alberta Journal of Educational Research, December, 1955. p. 46.

¹³Buros, The Third Mental Measurements Yearbook, op. cit., p. 22.

function, and the authors are justified in retaining this type in their tests.¹⁴

In spite of his severe criticism of the "N" type of answer, Schnell also has some kind words regarding the Iowa Test:

Only approximate answers are required in 8 of the 31 problem-solving items in Part III, Form O, of the Advanced Battery. Since an exact answer to a practical problem often may be less meaningful than a good approximation, it is encouraging to find this type of item in standardized tests. Surely few, if any, educators will deny the fact that if $21/32$ of a farm's acreage is planted in corn, the most common sense interpretation is that about $2/3$ is planted in corn.¹⁵

Unless it is specifically constructed for a particular investigation, it is doubtful that any test can be found with all the exact characteristics desired in a measuring instrument. Since it was impractical in this investigation to build a new test, a good standardized test seemed to be the logical instrument to use. The Iowa Test D appears to have met the purposes of this study to as great an extent as any such test could be expected to do. The writer feels that Brownell aptly summarized its suitability when he said: "There probably is no better battery of arithmetic tests on the market."¹⁶

¹⁴Ibid., p. 422.

¹⁵Ibid., p. 423.

¹⁶Ibid., p. 422.

CHAPTER V

PRESENTATION OF DATA

This chapter will be devoted to a comparison of achievement in the different concepts tested. For purposes of organization, the problems have been classified according to the following nine categories: (1) simple computation, (2) averages, (3) cost, (4) per cent, (5) fractions, (6) use of formulas, (7) approximations, (8) telling time, (9) interpretation of diagrams. Since many of the problems test more than one of these concepts, such problems are included in more than one category. Also, since this part of the study is concerned with achievement rather than diagnosis of difficulties, percentages are based on total possible answers, since omission of a problem may indicate the pupil's inability to solve it.

Since all verbal problems require a certain amount of skill in reading, it is impossible to say of a problem that it tests that skill. Hence, no attempt has been made to measure achievement in this area, although difficulties in reading are diagnosed in Chapter VI. Since it may be argued that all problems require skill in computation, computation has been made the first category for comparison.

I. COMPUTATION

Problems number 74, 75, 76, 78, 81, 87, 90, 91, 92, 94, 95, and 96 test computational skills. Tables III and IV below give the statistics on achievement in these problems.

TABLE III

ACHIEVEMENT IN PROBLEMS TESTING SKILL IN COMPUTATION

Sample	P.S.	C.S.	Per cent C.S.
Urban - Boys	732	566	77.32
Girls	1008	740	73.41
Combined	1740	1306	75.06
Town - Boys	612	458	74.84
Girls	516	371	71.89
Combined	1128	829	73.49
G.R. - Boys	576	430	74.65
Girls	444	326	73.42
Combined	1020	756	74.12
U.R. - Boys	456	299	65.57
Girls	456	314	68.86
Combined	912	613	67.21
Total - Boys	2376	1753	73.78
Sample Girls	2424	1751	72.22
Combined	4800	3504	73.00

Legend

P.S. possible score
C.S. correct score

G.R. graded rural
U.R. ungraded rural

It may be noted that the order of achievement is identical with that on the complete problem test, i.e. urban, graded rural, town, and ungraded rural.

TABLE IV
DIFFERENTIAL ACHIEVEMENT IN COMPUTATION

Samples	D.	S.E.D.	C.R.	Sig.
BOYS				
Urban - Town	2.48	4.17	.59	---
Urban - G.R.	2.67	4.19	.64	---
Urban - U.R.	11.75	4.41	2.66	.01
Town - G.R.	.19	4.34	.04	---
Town - U.R.	9.27	4.33	2.14	.05
G.R. - U.R.	9.08	4.39	2.07	.05
GIRLS				
Urban - Town	1.52	3.93	.39	---
Urban - G.R.	- .01	4.18	.00	---
Urban - U.R.	4.55	4.01	1.13	---
Town - G.R.	- 1.53	4.70	.33	---
Town - U.R.	3.03	4.52	.67	---
G.R. - U.R.	4.56	4.74	.96	---
BOYS - GIRLS				
Urban	3.91	3.66	1.07	---
Town	2.95	4.38	.67	---
Graded Rural	1.23	4.68	.26	---
Ungraded Rural	- 3.29	4.45	.74	---
Total Sample	1.56	2.11	.74	---
BOYS AND GIRLS COMBINED				
Urban - Town	1.57	2.85	.55	---
Urban - G.R.	.94	4.02	.23	---
Urban - U.R.	7.85	2.90	2.71	.01
Town - G.R.	- .63	3.19	.19	---
Town - U.R.	6.28	3.13	2.01	.05
G.R. - U.R.	6.91	3.22	2.15	.05

Legend

D. difference
C.R. critical ratio
G.R. graded rural

S.E.D. standard error of
difference
Sig. significance
U.R. ungraded rural

The minus sign indicates a difference in favor of the second variable.

Tables III and IV, and all tables like them in this chapter, may be interpreted as follows: In Table III, the first column shows the division of the sample by type of school and sex. "Combined" means the total sample from the type of school under consideration. The possible score is the number of pupils times the number of questions in this particular category. The correct score is the number of correct solutions to these questions. The third column gives the per cent of correct solutions out of the possible number.

In Table IV, the first column gives the samples compared; the second column indicates the difference between their percentages of achievement; the third column gives the standard error of this difference; the fourth column shows the critical ratio between Columns II and III; and the last column indicates the level of significance in the difference.

For ready reference, the legend has been given below each table throughout the chapter.

The following formulas were used in computing the S.E.D. and the C.R.:

$$\text{S.E.D.} = \sqrt{PQ \left[\frac{1}{N_1} + \frac{1}{N_2} \right]} \qquad \text{C.R.} = \frac{D}{\text{S.E.D.}}$$

The critical ratio was tested against Garrett's Table of t^1 for significance at the .05 and .01 levels only.

¹Henry E. Garrett, Statistics in Psychology and Education, Fourth Edition, (New York: Longmans, Green and Co., 1953.) p. 427.

Table IV shows that, with the exception of pupils from ungraded rural schools who were statistically inferior in both the boys and the total sample, the differences are not significant.

II. AVERAGES

Only two problems were directly concerned with averages. These were numbers 77 and 79. Tables V and VI present the statistics on these.

TABLE V
ACHIEVEMENT IN PROBLEMS INVOLVING AVERAGES

Sample	P.S.	C.S.	Per cent C. S.
Urban - Boys	122	93	76.23
Girls	168	121	72.02
Combined	290	214	73.79
Town - Boys	102	69	67.65
Girls	86	54	62.79
Combined	188	123	65.43
G.R. - Boys	96	69	71.88
Girls	74	50	67.57
Combined	170	119	70.00
U.R. - Boys	76	44	57.89
Girls	76	44	57.89
Combined	152	88	57.89
Total - Boys	396	275	69.44
Sample Girls	404	269	66.58
Combined	800	544	68.00

Legend

P.S. possible score
C.S. correct score

G.R. graded rural
U.R. ungraded rural

TABLE VI
DIFFERENTIAL ACHIEVEMENT IN PROBLEMS IN AVERAGES

Samples	D.	S.E.D.	C.R.	Sig.
BOYS				
Urban - Town	8.58	9.01	.95	---
Urban - G.R.	4.35	10.09	.43	---
Urban - U.R.	18.34	9.71	1.89	---
Town - G.R.	- 4.23	9.93	.43	---
Town - U.R.	9.76	9.48	1.03	---
G.R. - U.R.	13.99	9.90	1.41	---
GIRLS				
Urban - Town	9.23	8.91	1.04	---
Urban - G.R.	4.45	9.73	.46	---
Urban - U.R.	14.13	8.93	1.58	---
Town - G.R.	- 4.78	10.33	.46	---
Town - U.R.	4.90	9.49	.52	---
G.R. - U.R.	9.68	10.21	.95	---
BOYS - GIRLS				
Urban	3.44	8.81	.39	---
Town	4.86	9.54	.51	---
Graded Rural	4.31	10.78	.39	---
Ungraded Rural	0.00	0.00	.00	---
Total Sample	2.86	4.81	.59	---
BOYS AND GIRLS COMBINED				
Urban - Town	8.36	6.51	1.28	---
Urban - G.R.	3.79	6.94	.55	---
Urban - U.R.	15.90	6.54	2.43	.05
Town - G.R.	- 4.57	7.16	.64	---
Town - U.R.	7.54	6.71	1.12	---
G.R. - U.R.	12.11	7.11	1.70	---

Legend

D. difference	S.E.D. standard error of difference
C.R. critical ratio	Sig. significance
G.R. graded rural	U.R. ungraded rural

The minus sign indicates a difference in favor of the second variable.

It is interesting to note in Tables V and VI that, although the percentage differences are fairly large, the sample is so small that the standard error becomes large enough to make differences in achievement insignificant. The only significant difference is in the combined sample where urban pupils showed superiority over the ungraded rural pupils at the .05 level. The order of achievement remained the same as for computation.

III. COST

For purposes of classification, the third group consists of problems dealing with cost. Questions 80, 81, 83, 94, 95, 100, 102, 103, and 104 were of this type. Tables VII and VIII on pages 36 and 37 respectively illustrate the achievement on these questions.

TABLE VII
ACHIEVEMENT IN PROBLEMS IN FINDING COST

Sample	P.S.	C.S.	Per cent C.S.
Urban - Boys	549	265	48.27
Girls	756	335	44.31
Combined	1305	600	45.98
Town - Boys	459	218	47.49
Girls	387	184	47.55
Combined	846	402	47.52
G.R. - Boys	432	211	48.84
Girls	333	166	49.85
Combined	765	377	49.28
U.R. - Boys	342	146	42.69
Girls	342	156	45.61
Combined	684	302	44.15
Total - Boys	1782	840	47.14
Sample Girls	1818	841	46.26
Combined	3600	1681	46.69

Legend

P.S. possible score
C.S. correct score

G.R. graded rural
U.R. ungraded rural

It is interesting to note in Table VII that the sequence of rank order has changed from that appearing in the two previous types of problems. In cost problems, the order of achievement is: graded rural, town, urban, and ungraded rural. Table VIII on page 37 shows, however, that the differences are significant only between graded rural and ungraded rural schools, and this is at the .05 level only.

TABLE VIII
DIFFERENTIAL ACHIEVEMENT IN "COST" PROBLEMS

Samples	D.	S.E.D.	C.R.	Sig.
BOYS				
Urban - Town	.78	3.03	.26	---
Urban - G.R.	- .57	3.12	.18	---
Urban - U.R.	5.58	3.13	1.78	---
Town - G.R.	- 1.35	3.23	.42	---
Town - U.R.	4.80	3.22	1.49	---
G.R. - U.R.	6.15	3.30	1.86	---
GIRLS				
Urban - Town	- 3.18	2.87	1.11	---
Urban - G.R.	- 5.54	3.09	1.79	---
Urban - U.R.	- 1.30	2.93	.44	---
Town - G.R.	- 2.30	3.64	.63	---
Town - U.R.	1.94	3.46	.56	---
G.R. - U.R.	4.24	3.67	1.16	---
BOYS - GIRLS				
Urban	3.96	2.55	1.55	---
Town	- .06	3.28	.02	---
Graded Rural	- 1.01	3.59	.28	---
Ungraded Rural	- 2.92	3.37	.87	---
Total Sample	.88	1.56	.56	---
BOYS AND GIRLS COMBINED				
Urban - Town	- 1.54	2.06	.75	---
Urban - G.R.	- 3.30	2.17	1.52	---
Urban - U.R.	1.83	2.13	.86	---
Town - G.R.	- 1.76	2.42	.73	---
Town - U.R.	3.37	2.36	1.43	---
G.R. - U.R.	5.13	2.45	2.09	.05

Legend

D. difference
C.R. critical ratio
G.R. graded rural

S.E.D. standard error of difference
Sig. significance
U.R. ungraded rural

The minus sign indicates a difference in favor of the second variable.

IV. PERCENTAGE

Only three problems on the test required knowledge of percentage for correct solutions. These were numbers 82, 93, and 104. A summary of the achievement on these three problems is given in Tables IX and X.

TABLE IX
ACHIEVEMENT IN PERCENTAGE PROBLEMS

Sample	P.S.	C.S.	Per cent C.S.
Urban - Boys	183	75	40.98
Girls	252	97	38.49
Combined	435	172	39.54
Town - Boys	153	58	37.91
Girls	129	48	37.21
Combined	282	106	37.59
G.R. - Boys	144	54	37.50
Girls	111	42	37.84
Combined	255	96	37.65
U.R. - Boys	114	43	37.72
Girls	114	40	35.09
Combined	228	83	36.40
Total - Boys	594	230	38.72
Sample Girls	606	227	37.46
Combined	1200	457	38.08

Legend

P.S. possible score
C.S. correct score

G.R. graded rural
U.R. ungraded rural

While the rank order of achievement is back to the familiar sequence of urban, graded rural, town, and ungraded rural, Table X on page 39 shows that the differences were too small to be statistically significant.

TABLE X
DIFFERENTIAL ACHIEVEMENT IN PERCENTAGE PROBLEMS

Samples	D.	S.E.D.	C.R.	Sig.
BOYS				
Urban - Town	3.07	4.32	.71	---
Urban - G.R.	3.48	4.37	.79	---
Urban - U.R.	3.26	4.69	.69	---
Town - G.R.	.41	5.18	.08	---
Town - U.R.	.19	4.68	.04	---
G.R. - U.R.	- .22	4.71	.05	---
GIRLS				
Urban - Town	1.28	4.09	.31	---
Urban - G.R.	.65	4.32	.15	---
Urban - U.R.	3.40	4.18	.81	---
Town - G.R.	- .63	5.07	.12	---
Town - U.R.	2.12	4.64	.46	---
G.R. - U.R.	2.75	4.86	.57	---
BOYS - GIRLS				
Urban	2.49	3.86	.65	---
Town	.70	4.49	.16	---
Graded Rural	- .34	4.76	.07	---
Ungraded Rural	2.63	4.82	.55	---
Total Sample	1.26	2.19	.58	---
BOYS AND GIRLS COMBINED				
Urban - Town	1.95	2.95	.66	---
Urban - G.R.	1.89	3.04	.62	---
Urban - U.R.	3.14	3.10	1.01	---
Town - G.R.	- .06	3.31	.02	---
Town - U.R.	1.19	3.29	.36	---
G.R. - U.R.	1.25	3.37	.37	---

Legend

D. difference	S.E.D. standard error of difference
C.R. critical ratio	Sig. significance
G.R. graded rural	U.R. ungraded rural

The minus sign indicates a difference in favor of the second variable.

V. FRACTIONS

The following six problems require work with fractions for their solution: 83, 85, 86, 88, 89, and 101. Tables XI and XII show statistically the achievement on these problems.

TABLE XI
ACHIEVEMENT IN PROBLEMS ON FRACTIONS

Sample	P.S.	C.S.	Per cent C.S.
Urban - Boys	366	222	60.66
Girls	504	274	54.37
Combined	870	496	57.01
Town - Boys	306	181	59.15
Girls	258	135	52.33
Combined	564	316	56.03
G.R. - Boys	288	166	57.64
Girls	222	123	55.41
Combined	510	289	56.67
U.R. - Boys	228	108	47.37
Girls	228	116	50.88
Combined	456	224	49.10
Total - Boys	1188	677	56.99
Sample Girls	1212	648	53.47
Combined	2400	1325	55.21

Legend

P.S. possible score
C.S. correct score

G.R. graded rural
U.R. ungraded rural

Table XI shows the rank order in problems on fractions again to be: urban, graded rural, town, and ungraded rural. Differential achievement in this type of questions is given in Table XII on page 41.

TABLE XII
DIFFERENTIAL ACHIEVEMENT IN FRACTION PROBLEMS

Samples	D.	S.E.D.	C.R.	Sig.
BOYS				
Urban - Town	1.51	4.64	.33	---
Urban - G.R.	3.02	4.66	.65	---
Urban - U.R.	13.29	4.52	2.94	.01
Town - G.R.	1.51	5.39	.28	---
Town - U.R.	11.78	4.63	2.54	.05
G.R. - U.R.	10.27	4.63	2.22	.05
GIRLS				
Urban - Town	2.04	4.08	.50	---
Urban - G.R.	- 1.04	4.42	.24	---
Urban - U.R.	3.49	4.19	.83	---
Town - G.R.	- 3.08	4.93	.62	---
Town - U.R.	1.45	4.69	.31	---
G.R. - U.R.	4.53	4.51	1.00	---
BOYS - GIRLS				
Urban	6.29	3.94	1.59	---
Town	6.82	4.70	1.45	---
Graded Rural	2.23	5.05	.44	---
Ungraded Rural	- 3.51	4.59	.76	---
Total Sample	3.52	2.25	1.56	---
BOYS AND GIRLS COMBINED				
Urban - Town	.98	3.06	.32	---
Urban - G.R.	.34	3.72	.09	---
Urban - U.R.	7.91	3.06	2.58	.01
Town - G.R.	- .64	3.44	.19	---
Town - U.R.	6.93	3.30	2.10	.05
G.R. - U.R.	7.57	3.39	2.23	.05

Legend

D. difference
C.R. critical ratio
G.R. graded rural

S.E.D. standard error of difference
Sig. significance
U.R. ungraded rural

The minus sign indicates a difference in favor of the second variable.

Table XII indicates significantly inferior achievement on the part of ungraded rural pupils in problems requiring the use of fractions. Although, with the exception of the ungraded rural pupils, boys scored higher than girls, this difference was not significant in any comparison. The poorest achievers were the boys from ungraded rural schools.

VI. FORMULAS

Problems number 84, 97, 98, 99, 100, and 101 require the use of formulas for finding areas and volumes. Table XIII on page 43 indicates a general weakness in the use of formulas with an average achievement of only 28 per cent. The rank order of achievement was also unusual in this type of problems, with town pupils at the top, followed by those from graded rural, ungraded rural, and urban schools in that order. It is particularly interesting to note that urban pupils were the poorest achievers in handling formulas.

TABLE XIII
ACHIEVEMENT IN PROBLEMS REQUIRING FORMULAS

Sample	P.S.	C.S.	Per cent C.S.
Urban - Boys	366	107	29.23
Girls	504	115	22.82
Combined	870	222	25.52
Town - Boys	306	109	35.62
Girls	258	70	27.13
Combined	564	179	31.74
G.R. - Boys	288	98	34.03
Girls	222	56	25.23
Combined	510	154	30.19
U.R. - Boys	228	72	31.58
Girls	228	56	24.56
Combined	456	128	28.07
Total - Boys	1188	386	32.49
Sample Girls	1212	297	24.50
Combined	2400	683	28.46

Legend

P.S. possible score
C.S. correct score

G.R. graded rural
U.R. ungraded rural

Table XIV on page 44 shows that both urban boys and girls were inferior to town boys and girls in working problems with formulas. In the total sample, urban pupils proved inferior to pupils from both town and graded rural schools, significant at the .01 level of confidence. In this type of problem, boys were superior to girls in every type of school, also significant at the .01 level.

TABLE XIV
DIFFERENTIAL ACHIEVEMENT IN FORMULA PROBLEMS

Samples	D.	S.E.D.	C.R.	Sig.
BOYS				
Urban - Town	- 6.39	2.49	2.57	.05
Urban - G.R.	- 4.80	2.48	1.94	---
Urban - U.R.	- 2.35	2.56	.92	---
Town - G.R.	1.59	2.86	.56	---
Town - U.R.	4.04	2.93	1.38	---
G.R. - U.R.	2.45	2.89	.85	---
GIRLS				
Urban - Town	- 4.31	1.59	2.70	.01
Urban - G.R.	- 2.41	1.93	1.25	---
Urban - U.R.	- 1.74	1.55	1.12	---
Town - G.R.	1.90	2.35	.81	---
Town - U.R.	2.57	2.35	1.09	---
G.R. - U.R.	.67	2.35	.29	---
BOYS - GIRLS				
Urban	6.41	1.77	3.62	.01
Town	8.49	2.04	4.16	.01
Graded Rural	8.80	2.62	3.36	.01
Ungraded Rural	7.02	2.61	2.69	.01
Total Sample	7.99	1.16	6.89	.01
BOYS AND GIRLS COMBINED				
Urban - Town	- 6.22	1.54	4.04	.01
Urban - G.R.	- 4.67	1.55	3.01	.01
Urban - U.R.	- 2.55	1.55	1.65	---
Town - G.R.	1.55	1.89	.82	---
Town - U.R.	3.67	1.88	1.95	---
G.R. - U.R.	2.12	1.88	1.13	---

Legend

D. difference	S.E.D. standard error of difference
C.R. critical ratio	Sig. significance
G.R. graded rural	U.R. ungraded rural

The minus sign indicates a difference in favor of the second variable.

VII. APPROXIMATIONS

Problems number 86, 87, 88, 89, 90, 93, 101, and 104 require approximations in the answers. Achievement in these problems is indicated in Table XV below and in Table XVI on page 46.

TABLE XV
ACHIEVEMENT IN APPROXIMATIONS

Sample	P.S.	C.S.	Per cent C.S.
Urban - Boys	488	218	44.67
Girls	672	277	41.22
Combined	1160	495	42.67
Town - Boys	408	187	45.86
Girls	344	140	40.69
Combined	752	327	43.48
G.R. - Boys	384	179	46.61
Girls	296	130	43.92
Combined	680	309	45.44
U.R. - Boys	304	109	35.86
Girls	304	112	36.84
Combined	608	221	36.35
Total - Boys	1584	693	43.75
Sample Girls	1616	659	40.78
Combined	3200	1352	42.25

Legend

P.S. possible score
C.S. correct score

G.R. graded rural
U.R. ungraded rural

In rank order of performance, the graded rural pupils were at the top in this type of problems, followed by town, urban, and ungraded rural pupils in that order.

TABLE XVI
DIFFERENTIAL ACHIEVEMENT IN APPROXIMATIONS

Samples	D.	S.E.D.	C.R.	Sig.
BOYS				
Urban - Town	- 1.19	3.04	.39	---
Urban - G.R.	- 1.94	3.11	.62	---
Urban - U.R.	8.81	2.91	3.03	.01
Town - G.R.	- .75	3.29	.23	---
Town - U.R.	10.00	3.07	3.26	.01
G.R. - U.R.	10.75	3.14	3.42	.01
GIRLS				
Urban - Town	.53	2.72	.19	---
Urban - G.R.	- 2.70	2.97	.91	---
Urban - U.R.	4.38	2.69	1.63	---
Town - G.R.	- 3.23	3.35	.96	---
Town - U.R.	3.85	3.17	1.21	---
G.R. - U.R.	7.08	3.28	2.16	.05
BOYS - GIRLS				
Urban	3.45	2.55	1.35	---
Town	5.17	3.07	1.68	---
Graded Rural	2.69	3.49	.77	---
Ungraded Rural	- .98	2.95	.33	---
Total Sample	2.97	1.49	1.99	.05
BOYS AND GIRLS COMBINED				
Urban - Town	- .81	2.02	.40	---
Urban - G.R.	- 2.77	2.13	1.30	---
Urban - U.R.	6.32	1.97	3.21	.01
Town - G.R.	- 1.96	2.35	.83	---
Town - U.R.	7.13	2.17	3.29	.01
G.R. - U.R.	9.09	2.27	4.00	.01

Legend

D. difference	S.E.D. standard error of difference
C.R. critical ratio	Sig. significance
G.R. graded rural	U.R. ungraded rural

The minus sign indicates a difference in favor of the second variable.

It is obvious from Tables XV and XVI that ungraded rural pupils are inferior to those from each of the other three types of schools in approximating an answer. This difference is significant at the .01 level of confidence. In this skill, ungraded rural girls are inferior only to those from graded rural schools, and then only at the .05 level. In the total sample, in approximating answers girls were also found to be weaker than boys, significant at the .05 level. The poorest achievers in this category were the ungraded rural boys who were significantly inferior to the boys from all three other types of schools at the .01 level.

VIII. TELLING TIME

Only problem number 90 deals with telling time, so the sample here is very small, but since this problem does not fall into any other category except for computation, it has been included as a separate class. Tables XVII and XVIII on pages 48 and 49 respectively give the achievement statistics for this problem.

TABLE XVII
ACHIEVEMENT IN PROBLEM ON TELLING TIME

Sample	P.S.	C.S.	Per cent C.S.
Urban - Boys	61	31	50.82
Girls	84	42	50.00
Combined	145	73	50.34
Town - Boys	51	29	56.86
Girls	43	20	46.67
Combined	94	49	52.13
G.R. - Boys	48	30	62.50
Girls	37	19	51.35
Combined	85	49	57.65
U.R. - Boys	38	11	28.95
Girls	38	16	42.11
Combined	76	27	35.53
Total - Boys	198	101	51.01
Sample Girls	202	97	48.02
Combined	400	198	49.50

Legend

P.S. possible score
C.S. correct score

G.R. graded rural
U.R. ungraded rural

Table XVII would indicate a wide variety of achievement in this type of problems, but the small sample makes it impossible to state with any authority that such differences are reliable. The rank order of achievement in this small sample was graded rural schools, town schools, urban schools, and ungraded rural schools in that order. The significance of the differences has been computed in Table XVIII on page 49.

TABLE XVIII
DIFFERENTIAL ACHIEVEMENT IN TELLING TIME

Samples	D.	S.E.D.	C.R.	Sig.
BOYS				
Urban - Town	- 6.04	10.10	.59	---
Urban - G.R.	-11.68	10.87	1.07	---
Urban - U.R.	21.87	7.92	2.76	.01
Town - G.R.	- 7.64	11.99	.64	---
Town - U.R.	27.91	8.68	3.22	.01
G.R. - U.R.	33.55	9.24	3.63	.01
GIRLS				
Urban - Town	3.33	9.06	.37	---
Urban - G.R.	- 1.35	9.99	.14	---
Urban - U.R.	7.89	7.35	1.07	---
Town - G.R.	- 4.68	10.98	.43	---
Town - U.R.	4.56	9.87	.46	---
G.R. - U.R.	9.24	10.40	.89	---
BOYS - GIRLS				
Urban	.82	8.48	.09	---
Town	10.19	10.66	.96	---
Graded Rural	11.15	12.39	.89	---
Ungraded Rural	-13.16	8.01	1.64	---
Total Sample	2.99	4.94	.61	---
BOYS AND GIRLS COMBINED				
Urban - Town	- 1.79	6.78	.26	---
Urban - G.R.	- 7.31	7.36	.99	---
Urban - U.R.	14.81	5.99	2.47	.05
Town - G.R.	- 5.52	8.21	.67	---
Town - U.R.	16.60	6.63	2.50	.05
G.R. - U.R.	22.12	7.14	3.09	.01

Legend

D. difference	S.E.D. standard error of difference
C.R. critical ratio	Sig. significance
G.R. graded rural	U.R. ungraded rural

The minus sign indicates a difference in favor of the second variable.

According to Table XVIII, the boys from ungraded rural schools were far below those from other types of schools in achievement, with the difference significant at .01 in each case. There was no significant difference between boys and girls, but in the combined sample, ungraded rural pupils showed significantly inferior achievement, at the .05 level as compared with urban and town pupils, and at the .01 level when compared with those from graded rural schools.

IX. DIAGRAMS

The final category of problems consisted of two groups, one based on a road map, and the other on a floor plan of a house. Correct interpretation of the diagram was required for the right solution to each of the twelve questions in these series of problems. Achievement in this type is summarized in Table XIX on page 51, and Table XX on page 52.

TABLE XIX
ACHIEVEMENT IN PROBLEMS BASED ON DIAGRAMS

Sample	P.S.	C.S.	Per cent C.S.
Urban - Boys	732	309	42.21
Girls	1008	356	35.32
Combined	1740	665	38.22
Town - Boys	612	251	41.01
Girls	516	193	37.40
Combined	1128	444	39.36
G.R. - Boys	576	247	42.88
Girls	444	186	41.89
Combined	1020	433	42.45
U.R. - Boys	456	178	39.04
Girls	456	170	37.28
Combined	912	348	38.16
Total - Boys	2376	985	41.46
Sample Girls	2424	905	37.33
Combined	4800	1890	39.38

Legend

P.S. possible score
C.S. correct score

G.R. graded rural
U.R. ungraded rural

Table XIX above and Table XX on page 52 show that urban girls were particularly weak in these problems. They were inferior to the boys and to graded rural girls at the .01 level, and brought down the average for the combined urban sample to such an extent that urban pupils scored significantly lower than graded rural pupils at the .01 level. Ungraded rural pupils were also inferior to graded rural pupils at the .05 level. In the total sample, boys proved superior to girls, significant at the .01 level.

TABLE XX

DIFFERENTIAL ACHIEVEMENT IN INTERPRETATION OF DIAGRAMS

Samples	D.	S.E.D.	C.R.	Sig.
BOYS				
Urban - Town	1.20	2.28	.53	---
Urban - G.R.	- .67	2.37	.28	---
Urban - U.R.	3.17	2.42	1.31	---
Town - G.R.	- 1.87	2.43	.77	---
Town - U.R.	1.97	2.48	.99	---
G.R. - U.R.	3.84	2.56	1.50	---
GIRLS				
Urban - Town	- 2.08	1.97	1.06	---
Urban - G.R.	- 6.57	2.19	3.00	.01
Urban - U.R.	- 1.96	2.05	.96	---
Town - G.R.	- 4.49	2.56	1.75	---
Town - U.R.	.12	2.39	.05	---
G.R. - U.R.	4.61	2.63	1.75	---
BOYS - GIRLS				
Urban	6.89	1.88	3.66	.01
Town	3.61	2.34	1.54	---
Graded Rural	.99	2.68	.37	---
Ungraded Rural	1.76	2.53	.69	---
Total Sample	4.13	1.14	3.62	.01
BOYS AND GIRLS COMBINED				
Urban - Town	- 1.14	1.48	.77	---
Urban - G.R.	- 4.23	1.59	2.66	.01
Urban - U.R.	.06	1.56	.04	---
Town - G.R.	- 3.09	1.77	1.75	---
Town - U.R.	1.20	1.73	.69	---
G.R. - U.R.	4.29	1.83	2.34	.05

Legend

D. Difference

C.R. critical ratio

G.R. graded rural

S.E.D. standard error of difference

Sig. significance

U.R. ungraded rural

The minus sign indicates a difference in favor of the second variable.

X. ALL CATEGORIES

In addition to the comparison of achievement in each type of problems, it is interesting and useful to compare the results obtained in all the different categories. As a basis of comparison, the percentage of correct solutions on the complete problem test has been compared with each type of problems in turn. Table XXI below and Table XXII on page 54 show this comparison.

TABLE XXI
ACHIEVEMENT IN ALL TYPES OF PROBLEMS

Type of Problems	P.S.	C.S.	Per cent C.S.
Complete Test	12400	6931	55.89
Computation	4800	3504	73.00
Averages	800	544	68.00
Cost	3600	1681	46.69
Per cent	1200	457	38.08
Fractions	2400	1325	55.21
Formulas	2400	683	28.46
Approximations	3200	1352	42.25
Time	400	198	49.50
Diagrams	4800	1890	39.38

Legend

P.S. possible score

C.S. correct score

Using the average achievement of 55.89% as the basis of comparison, we find that in solving problems which test computation and ability to find an average, the pupils

reached a high achievement. In working problems involving fractions, achievement was the same as the average for the complete problem test, while in all other types of problems, the pupils scored below the average for the whole test. Table XXII below indicates the significance of the difference above or below the test average for each category.

TABLE XXII

DIFFERENTIAL ACHIEVEMENT BETWEEN THE TOTAL PROBLEM TEST
AND EACH TYPE OF PROBLEMS

Total Test Compared with	D.	S.E.D.	C.R.	Sig.
Computation	-17.11	1.09	15.69	.01
Averages	-12.11	2.13	5.69	.01
Cost	9.20	.97	9.48	.01
Per cent	17.81	1.39	12.81	.01
Fractions	.68	1.24	.55	---
Formulas	27.43	.89	30.82	.01
Approximations	13.64	.96	14.21	.01
Time	6.39	2.67	2.39	.05
Diagrams	16.51	.79	20.89	.01

Legend

D. difference S.E.D. standard error of difference
C.R. critical ratio Sig. significance

The minus sign indicates that "Computation" and "Average" problems were above the test average.

Table XXII indicates that, with the exception of "fraction" problems where there was no significant difference, and "time" problems where the difference was at the .05 level of significance, all other categories were either above or

below the test average at the .01 level. The poorest achievement was found in problems requiring the use of formulas, while those based on diagrams, per cent, and approximation also had a high critical ratio.

XI. SUMMARY

The tables in this chapter indicate that the inferior achievement of pupils in ungraded rural schools is consistent in almost all types of problems, a notable exception being problems involving per cent, where no significant difference was found.

Another interesting fact is the inferior achievement of urban pupils in problems requiring the use of formulas. Here pupils from city schools were significantly below town and graded rural pupils, and had insignificantly lower scores than ungraded rural pupils.

As for sex differences, while boys generally scored higher than girls, this was usually the reverse in the case of ungraded rural schools. The only significant difference between boys' and girls' achievement was in problems requiring formulas or diagrams, where the boys were significantly superior.

The most important fact noted is that there is a great difference in ability to solve different types of problems.

CHAPTER VI

PRESENTATION OF DATA CONTINUED

The first half of the data in this investigation dealt with achievement and was presented in Chapter V. The second half is an analysis of pupils' errors, and will be presented in this chapter.

Several factors in this part of the study made it necessary to alter the method in treatment of the raw data used in Chapter V. The first of these factors was the comparatively large number of problems omitted. Instructions to the pupils on the fly leaf of the Iowa Test read in part as follows:

Answer the questions in all parts of the test in the order in which they are given, but do not linger too long over difficult questions or problems. Skip them, and return to them later if time permits. ...¹

There may, therefore, be at least two reasons for an omission: lack of ability to solve the problem, and lack of time. That the latter is not entirely responsible is perhaps indicated by the number of omissions in the early part of the test. For these reasons, omissions

¹H.F. Spitzer and others, Iowa Every-Pupil Tests of Basic Skills, New Edition, Test D: Basic Arithmetic Skills - Form O, Advanced Battery - Grades 5-6-7-8-9. (Boston: Houghton, Mifflin Company, 1943.)

have been treated as a separate class of difficulty.

Another factor which made a change necessary is the N answer which does not lend itself to diagnosis. It also has been treated as a class in itself.

Because of the large number of omissions, and since this is a timed test, the writer feels that all statistics other than those on omissions are more valid when based upon attempted solutions than upon possible answers. This procedure is therefore used in reporting the second half of the data.

Since the difference between boys and girls in the various types of schools and that between the combined samples of the four classifications of schools yield all the information sought in this portion of the study, tables of significance have been limited to such comparisons only.

For purposes of differentiation, the grouping of errors will be as follows: (1) omissions, (2) the N answer, (3) computation, (4) reading and vocabulary, (5) use of denominate numbers, (6) processes in problem solving, (7) per cent, (8) fractions, (9) estimating answers, (10) interpreting drawings and diagrams, (11) formulas. The method of determining to which category each answer belongs is discussed in the appendix at the end of this thesis.

I. OMISSIONS

As stated on page 56 above, a large number of problems were omitted on the answer sheets, and therefore these were considered as a separate type of error. Tables XXIII and XXIV give the statistics of these omissions.

TABLE XXIII
PROBLEMS OMITTED

Sample	P.O.	E.O.	Per cent E.O.
Urban - Boys	1891	366	19.35
Girls	2604	417	16.01
Combined	4495	783	17.42
Town - Boys	1581	206	13.03
Girls	1333	140	10.50
Combined	2914	346	11.87
G.R. - Boys	1488	151	10.15
Girls	1147	100	8.72
Combined	2635	251	9.53
U.R. - Boys	1178	163	13.84
Girls	1178	87	7.39
Combined	2356	250	10.61
Total - Boys	6138	886	14.43
Sample Girls	6262	744	11.88
Combined	12400	1630	13.15

Legend

P.O. possible omissions
E.O. errors of omission

G.R. graded rural
U.R. ungraded rural

Table XXIII shows that, in spite of the fact that urban pupils had the best achievement on the problem test,

they omitted more problems than any others. On the other hand, graded rural pupils, who were second in achievement, omitted the fewest problems. The writer has no explanation for this.

TABLE XXIV
SIGNIFICANCE OF DIFFERENCES IN OMISSIONS

Samples	D.	S.E.D.	C.R.	Sig.
BOYS - GIRLS				
Urban	3.34	.53	6.30	.01
Town	2.53	.43	5.88	.01
Graded Rural	1.43	.37	4.21	.01
Ungraded Rural	6.45	.42	15.36	.01
Total Sample	2.55	.23	11.09	.01
BOYS AND GIRLS COMBINED				
Urban - Town	5.55	.24	23.13	.01
Urban - G.R.	8.70	.32	27.19	.01
Urban - U.R.	6.81	.35	19.46	.01
Town - G.R.	2.34	.29	8.07	.01
Town - U.R.	1.26	.31	4.06	.01
G.R. - U.R.	- 1.08	.28	3.86	.01

Legend

D. difference	S.E.D. standard error of difference
C.R. critical ratio	Sig. significance
G.R. graded rural	U.R. ungraded rural

The minus sign indicates a larger percentage of errors in the second variable.

Table XXIV shows that the differences in omissions are highly significant in every case. The order of schools from

lowest to highest percentage of omissions is graded rural, ungraded rural, town, and urban. In every type of school the boys omitted more problems than the girls. Both tables seem to indicate no relationship between the number of problems omitted and achievement on the total test.

II. THE N RESPONSE

The reader will recall that at the end of several questions, one choice of answer is N, meaning "none of the other three answers is correct". Since it is impossible to place an error which would lead to this choice in any other category, such incorrect responses have been treated as a separate class also. Tables XXV and XXVI give the statistics on this type of error.

TABLE XXV

NUMBER AND PERCENTAGES OF PUPILS GIVING INCORRECT
N RESPONSES

Sample	A.S.	N.R.	Per cent N.R.
Urban - Boys	851	154	18.10
Girls	1200	237	19.75
Combined	2051	391	19.06
Town - Boys	747	142	19.01
Girls	636	177	27.83
Combined	1383	319	23.07
G.R. - Boys	713	138	19.35
Girls	555	123	22.16
Combined	1268	261	20.58
U.R. - Boys	551	134	24.32
Girls	576	140	24.31
Combined	1127	274	24.31
Total - Boys	2862	568	19.85
Sample Girls	2967	677	22.81
Combined	5829	1245	21.36

Legend

A.S. attempted solutions
N.R. N responses

G.R. graded rural
U.R. ungraded rural

Table XXV shows that a very large percentage (21.36%) arrived at an N response even when it was wrong. This is probably so because a variety of incorrect solutions may result in an answer other than the three listed previous to the N. The order of types of schools making this error from lowest to highest percentage was urban, graded rural, town, and ungraded rural, the exact order of achievement on the

problem test.

TABLE XXVI
SIGNIFICANCE OF DIFFERENCES IN N RESPONSES

Samples	D.	S.E.D.	C.R.	Sig.
BOYS - GIRLS				
Urban	- 1.65	.84	1.96	.05
Town	- 8.82	1.24	7.11	.01
Graded Rural	- 2.81	1.17	2.40	.05
Ungraded Rural	.01	1.45	.01	---
Total Sample	- 2.96	.56	5.29	.01
BOYS AND GIRLS COMBINED				
Urban - Town	- 4.01	.74	5.42	.01
Urban - G.R.	- 1.52	.71	2.14	.05
Urban - U.R.	- 5.25	.79	6.65	.01
Town - G.R.	2.49	.85	2.93	.01
Town - U.R.	- 1.24	.95	1.31	---
G.R. - U.R.	- 3.73	.92	4.05	.01

Legend

D. difference	S.E.D. standard error of difference
C.R. critical ratio	Sig. significance
G.R. graded rural	U.R. ungraded rural

The minus sign indicates a higher percentage of errors in the second variable.

Table XXVI, page 62, indicates that differences in the number of N answers were generally significant both between schools and between sexes. In all but ungraded rural schools, girls made this error significantly more often than boys, although in urban and graded rural schools, the difference was significant at the .05 level only.

III. COMPUTATION

The relatively small percentage of errors found to be caused by inefficiency in computation is not necessarily a true picture of computation mistakes, since many errors of this type may have led to N responses. This may be equally true of other classifications to follow. However, the writer feels that for purposes of this study, the comparison of frequency of such errors gives a valid indication of differences. Table XXVII, page 63, and Table XXVIII on page 64 summarize these differences.

TABLE XXVII
ERRORS IN COMPUTATION

Sample	A.S.	C.E.	Per cent C.E.
Urban - Boys	543	35	6.45
Girls	757	76	10.04
Combined	1300	111	8.54
Town - Boys	463	45	9.72
Girls	404	35	8.66
Combined	867	80	9.23
G.R. - Boys	454	46	10.13
Girls	350	37	10.57
Combined	804	83	10.32
U.R. - Boys	348	41	11.78
Girls	362	42	11.60
Combined	710	83	11.69
Total - Boys	1808	167	9.24
Sample Girls	1873	190	10.14
Combined	3681	357	9.70

Legend

A.S. attempted solutions
C.E. computation errors

G.R. graded rural
U.R. ungraded rural

The rank order of schools from lowest to highest in percentage of computational errors was found to be urban, town, graded rural, and ungraded rural. It is interesting to note that this is the exact order of achievement in computational skills found by Climenhaga.² This would seem to indicate that computational skill carries over into problem solving.

TABLE XXVIII

SIGNIFICANCE OF DIFFERENCES IN COMPUTATIONAL ERRORS

Samples	D.	S.E.D.	C.R.	Sig.
BOYS - GIRLS				
Urban	- 3.59	.45	7.98	.01
Town	1.06	.62	1.71	---
Graded Rural	- .44	.75	.59	---
Ungraded Rural	.18	.88	.20	---
Total Sample	- .90	.32	2.81	.01
BOYS AND GIRLS COMBINED				
Urban - Town	- .69	.39	1.77	---
Urban - G.R.	- 1.69	.32	5.28	.01
Urban - U.R.	- 3.15	.47	6.70	.01
Town - G.R.	- 1.09	.48	2.27	.05
Town - U.R.	- 2.46	.53	4.64	.01
G.R. - U.R.	- 1.37	.57	2.40	.05

Legend

D. difference	S.E.D. standard error of difference
C.R. critical ratio	Sig. significance
G.R. graded rural	U.R. ungraded rural

The minus sign indicates a higher percentage of errors in the second variable.

²Clarence E. Climenhaga, "A Survey of Arithmetical Achievement of Grade Eight Pupils in Alberta Schools," The Alberta Journal of Educational Research, Dec., 1955. p. 41.

According to Table XXVIII, the only significant difference in computational errors between boys and girls was in urban schools. However, the difference here was great enough to make girls significantly inferior to the boys at the .01 level in the total sample.

Urban schools were significantly superior to both graded rural and ungraded rural at the .01 level, while town schools scored better than graded rural at the .05 level, and better than ungraded schools at the .01 level. Graded rural schools were significantly better than ungraded rural schools at the .05 level of confidence.

IV. READING AND VOCABULARY

Twenty-one of the suggested answers would be chosen by pupils making errors in reading or misunderstanding the vocabulary. Tables XXIX and XXX summarize the data for this type of answer.

TABLE XXIX
ERRORS IN READING AND VOCABULARY

Sample	A.S.	R.E.	Per cent R.E.
Urban - Boys	857	62	7.23
Girls	1220	132	10.82
Combined	2077	194	9.34
Town - Boys	771	77	9.99
Girls	675	92	13.63
Combined	1446	169	11.69
G.R. - Boys	736	87	11.82
Girls	595	76	12.77
Combined	1331	163	12.25
U.R. - Boys	580	86	14.83
Girls	627	92	14.67
Combined	1207	178	14.75
Total - Boys	2944	312	10.59
Sample Girls	3117	392	12.58
Combined	6061	704	11.62

Legend

A.S. attempted solutions
R.E. reading errors

G.R. graded rural
U.R. ungraded rural

Table XXIX indicates that a large number of errors resulted from inefficiency in reading and vocabulary. The rank order from lowest to highest percentage of errors was urban, town, graded rural, and ungraded rural. Table XXX shows the significance of the differences between these schools.

TABLE XXX
SIGNIFICANCE OF DIFFERENCES IN READING AND
VOCABULARY ERRORS

Samples	D.	S.E.D.	C.R.	Sig.
BOYS - GIRLS				
Urban	- 3.59	.39	9.21	.01
Town	- 3.64	.62	5.87	.01
Graded Rural	- .95	.68	1.39	---
Ungraded Rural	.16	.85	.19	---
Total Sample	- 1.99	.29	6.86	.01
BOYS AND GIRLS COMBINED				
Urban - Town	- 2.35	.36	6.53	.01
Urban - G.R.	- 2.91	.38	7.66	.01
Urban - U.R.	- 5.41	.84	6.44	.01
Town - G.R.	- .56	.45	1.24	---
Town - U.R.	- 3.06	.51	6.00	.01
G.R. - U.R.	- 2.50	.53	4.72	.01

Legend

D. difference	S.E.D. standard error of difference
C.R. critical ratio	Sig. significance
G.R. graded rural	U.R. ungraded rural

The minus sign indicates a higher percentage of errors in the second variable.

Table XXX shows that girls made more reading errors than the boys in urban and town schools, and also in the total sample, all significant at the .01 level of confidence. As far as schools were concerned, differences were found to be significant at the .01 level in every case except between town and graded rural schools.

V. DENOMINATE NUMBERS

Only two choices on the problem test indicated errors in the use of denominate numbers. This makes the sample very small, as shown in Tables XXXI and XXXII.

TABLE XXXI
ERRORS IN THE USE OF DENOMINATE NUMBERS

Sample	A.S.	D.N.E.	Per cent D.N.E.
Urban - Boys	87	5	5.75
Girls	132	9	6.82
Combined	219	14	6.39
Town - Boys	84	8	9.52
Girls	73	4	5.48
Combined	157	12	7.64
G.R. - Boys	84	15	17.86
Girls	66	5	7.58
Combined	150	20	13.33
U.R. - Boys	62	9	14.52
Girls	71	6	8.45
Combined	133	15	11.28
Total - Boys	317	37	11.64
Sample Girls	342	24	7.02
Combined	659	61	9.26

Legend

A.S. attempted solution G.R. graded rural
D.N.E. denominate number errors U.R. ungraded rural

As seen in Table XXXI, page 68, the small sample gives a wide variety of percentages. The order of schools from lowest to highest percentage of errors was urban, town, un-

graded rural, and graded rural. Table XXXII shows the significance of the differences between them.

TABLE XXXII
SIGNIFICANCE OF DIFFERENCES IN ERRORS
IN DENOMINATE NUMBERS

Samples	D.	S.E.D.	C.R.	Sig.
BOYS - GIRLS				
Urban	- 1.07	.86	1.24	---
Town	4.04	1.16	3.48	.01
Graded Rural	10.28	1.91	5.38	.01
Ungraded Rural	6.07	1.93	3.66	.01
Total Sample	4.62	.70	6.60	.01
BOYS AND GIRLS COMBINED				
Urban - Town	- 1.25	.73	1.71	---
Urban - G.R.	- 6.94	.98	7.08	.01
Urban - U.R.	- 4.89	.93	5.26	.01
Town - G.R.	- 5.69	1.15	4.95	.01
Town - U.R.	- 3.64	1.09	3.34	.01
G.R. - U.R.	2.05	1.46	1.40	---

Legend

D. difference	S.E.D. standard error of difference
C.R. critical ratio	Sig. significance
G.R. graded rural	U.R. ungraded rural

The minus sign indicates a higher percentage of errors in the second variable.

It may be seen in Table XXXII that the girls in this small sample handled denominate numbers much better than did the boys. Except in urban schools where the boys were significantly superior, the girls had fewer errors than boys in

denominate numbers.

Urban and town pupils were superior to both graded and ungraded rural pupils. No significant difference was found between urban and town nor between graded and ungraded rural students.

VI. PROCESSES

The reader will recall that in the chapter on related literature, reference was made to the effect on problem solving of understanding processes in arithmetic. Thirteen possible answers indicated errors in procedure in the problem test. Tables XXXIII and XXXIV on pages 71 and 72 indicate how these questions were handled.

The rank order from lowest to highest percentage of errors is urban, town, graded rural, and ungraded rural. In each type of school, girls had a higher percentage of errors than boys.

TABLE XXXIII
ERRORS IN FUNDAMENTAL PROCESSES

Sample	A.S.	E.F.P.	Per cent E.F.P.
Urban - Boys	529	35	6.62
Girls	750	61	8.13
Combined	1279	96	7.51
Town - Boys	471	35	7.43
Girls	414	38	9.18
Combined	885	73	8.25
G.R. - Boys	450	38	8.44
Girls	350	30	8.57
Combined	800	68	8.50
U.R. - Boys	345	34	9.86
Girls	365	41	11.23
Combined	710	75	10.56
Total - Boys	1795	142	7.91
Sample Girls	1879	170	9.05
Combined	3674	312	8.49

Legend

A.S. attempted solutions
E.F.P. errors in fundamental
processes

G.R. graded rural
U.R. ungraded rural.

Table XXXIV on page 72 shows that boys in urban and town schools, committed significantly fewer errors in processes than did the girls in these schools while in the other types of schools the differences were insignificant. In the total sample, boys were superior to girls, significant at the .01 level. Urban pupils committed fewer errors than did those from any of the other schools. Town and graded rural pupils also performed significantly better than ungraded rural pupils.

TABLE XXXIV

SIGNIFICANCE OF DIFFERENCES OF PERCENTAGE OF ERRORS IN
FUNDAMENTAL PROCESSES

Samples	D.	S.E.D.	C.R.	Sig.
BOYS - GIRLS				
Urban	- 1.51	.42	3.59	.01
Town	- 1.75	.56	3.13	.01
Graded Rural	- .13	.61	.21	---
Ungraded Rural	- 1.37	.79	1.73	---
Total Sample	- 1.14	.28	4.07	.01
BOYS AND GIRLS COMBINED				
Urban - Town	- .74	.34	2.18	.05
Urban - G.R.	- .99	.36	2.75	.01
Urban - U.R.	- 3.05	.42	7.26	.01
Town - G.R.	- .25	.41	.61	---
Town - U.R.	- 2.31	.47	4.92	.01
G.R. - U.R.	- 2.06	.49	4.20	.01

Legend

D. difference

S.E.D. standard error of difference

C.R. critical ratio

Sig. significance

G.R. graded rural

U.R. ungraded rural

The minus sign indicates a higher percentage of errors in the second variable.

VII. PER CENT

Only four of the suggested answers on the problem test could be diagnosed as resulting from lack of knowledge of per cent. Pupils' responses to these questions are summarized in Tables XXXV and XXXVI on pages 73 and 74.

TABLE XXXV
ERRORS IN PERCENTAGE PROBLEMS

Sample	A.S.	E.P.	Per cent E.P.
Urban - Boys	181	15	8.29
Girls	265	29	10.94
Combined	446	44	9.87
Town - Boys	164	11	6.71
Girls	143	20	13.99
Combined	307	31	10.10
G.R. - Boys	158	12	7.59
Girls	127	18	14.17
Combined	285	30	10.53
U.R. - Boys	122	16	13.11
Girls	136	19	13.97
Combined	258	35	13.57
Total - Boys	625	54	8.64
Sample Girls	671	86	12.82
Combined	1296	140	10.80

Legend

A.S. attempted solutions
E.P. errors in per cent

G.R. graded rural
U.R. ungraded rural

The rank order of percentage of errors from lowest to highest is again urban, town, graded rural, and ungraded rural. In each type of school, the boys had a lower percentage of errors than the girls. Significance of the differences is given in Table XXXVI.

TABLE XXXVI
SIGNIFICANCE OF DIFFERENCES IN PERCENTAGE ERRORS

Samples	D.	S.E.D.	C.R.	Sig.
BOYS - GIRLS				
Urban	- 2.65	.92	2.88	.01
Town	- 7.28	1.11	6.56	.01
Graded Rural	- 6.58	1.24	5.31	.01
Ungraded Rural	- .86	1.69	.51	---
Total Sample	- 4.18	.59	7.08	.01
BOYS AND GIRLS COMBINED				
Urban - Town	- .23	.74	.31	---
Urban - G.R.	- .66	.77	.86	---
Urban - U.R.	- 3.70	.91	4.03	.01
Town - G.R.	- .43	.85	.51	---
Town - U.R.	- 3.47	.98	3.54	.01
G.R. - U.R.	- 3.04	1.03	2.95	.01

Legend

D. difference	S.E.D. standard error of difference
C.R. critical ratio	Sig. significance
G.R. graded rural	U.R. ungraded rural

The minus sign indicates a higher percentage of errors in the second variable.

The difference between boys and girls is seen to be significant in every type of school except ungraded rural. In comparing schools, the writer found that pupils in the ungraded rural schools made more errors than did pupils in any of the others, significant at the .01 level. No significant differences were found among the other three types of schools.

VIII. FRACTIONS AND DECIMALS

For the sake of convenience, errors in fractions and decimals have been grouped together as shown in Tables XXXVII and XXXVIII.

TABLE XXXVII
ERRORS IN FRACTIONS AND DECIMALS

Sample	A.S.	E.F.D.	Per cent E.F.D.
Urban - Boys	264	15	5.68
Girls	384	25	6.51
Combined	648	40	6.17
Town - Boys	236	18	7.63
Girls	198	11	5.56
Combined	434	29	6.68
G.R. - Boys	225	19	8.44
Girls	178	17	9.55
Combined	403	36	8.93
U.R. - Boys	166	15	9.04
Girls	179	9	5.03
Combined	345	24	6.96
Total - Boys	891	67	7.52
Sample Girls	939	62	6.60
Combined	1830	129	7.05

Legend

A.S. attempted solutions
E.F.D. errors in fractions and decimals

G.R. graded rural
U.R. ungraded rural

The most interesting facts revealed by Table XXXVII are that the girls made fewer errors in fractions and decimals than did the boys, and that graded rural pupils had the highest percentage of these errors.

TABLE XXXVIII
SIGNIFICANCE OF DIFFERENCES IN FRACTION
AND DECIMAL ERRORS

Samples	D.	S.E.D.	C.R.	Sig.
BOYS - GIRLS				
Urban	- .83	.47	1.77	---
Town	2.07	.63	3.29	.01
Graded Rural	- 1.11	.90	1.23	---
Ungraded Rural	4.01	.73	5.49	.01
Total Sample	.92	.33	2.79	.01
BOYS AND GIRLS COMBINED				
Urban - Town	- .51	.39	1.31	---
Urban - G.R.	- 2.76	.47	5.87	.01
Urban - U.R.	- .79	.44	1.79	---
Town - G.R.	- 2.25	.53	4.25	.01
Town - U.R.	- .28	.49	.57	---
G.R. - U.R.	1.97	.58	3.39	.01

Legend

D. difference	S.E.D. standard error of difference
C.R. critical ratio	Sig. significance
G.R. graded rural	U.R. ungraded rural

The minus sign indicates a higher percentage of errors in the second variable.

According to Table XXXVIII, girls were significantly superior to boys in problems involving fractions and decimals in both town and ungraded rural schools. This superiority was also significant in the total sample. Graded rural pupils were found to be inferior in this type of problem to those from all the other types of schools.

IX. ESTIMATING ANSWERS

A large percentage of pupils were unable to estimate answers, as indicated in Tables XXXIX and XL.

TABLE XXXIX
ERRORS IN ESTIMATING ANSWERS

Sample	A.S.	E.E.	Per cent E.E.
Urban - Boys	307	25	8.14
Girls	456	66	14.47
Combined	763	91	11.93
Town - Boys	286	35	12.24
Girls	240	41	17.08
Combined	526	76	14.45
G.R. - Boys	272	36	13.24
Girls	213	32	15.02
Combined	485	68	14.02
U.R. - Boys	192	33	17.17
Girls	217	55	25.35
Combined	409	88	21.52
Total - Boys	1057	129	12.20
Sample Girls	1126	194	17.23
Combined	2183	323	14.80

Legend

A.S. attempted solutions
E.E. errors in estimating

G.R. graded rural
U.R. ungraded rural

The rank order from lowest to highest percentage of errors in estimates was urban, graded rural, town, and ungraded rural. Boys were better at estimating answers than were girls. The significance of the differences is given in Table XL.

TABLE XL
SIGNIFICANCE OF DIFFERENCES IN ESTIMATING ANSWERS

Samples	D.	S.E.D.	C.R.	Sig.
BOYS - GIRLS				
Urban	- 6.33	.80	7.91	.01
Town	- 4.84	1.27	3.81	.01
Graded Rural	- 1.78	1.29	1.38	---
Ungraded Rural	- 8.18	2.06	3.97	.01
Total Sample	- 5.03	.62	8.11	.01
BOYS AND GIRLS COMBINED				
Urban - Town	- 2.52	.35	7.20	.01
Urban - G.R.	- 2.09	.45	4.64	.01
Urban - U.R.	- 9.59	.98	9.79	.01
Town - G.R.	.43	.89	.40	---
Town - U.R.	- 7.07	1.16	6.09	.01
G.R. - U.R.	- 7.50	1.17	6.41	.01

Legend

D. difference	S.E.D. standard error of difference
C.R. critical ratio	Sig. significance
G.R. graded rural	U.R. ungraded rural

The minus sign indicates a higher percentage of errors in the second variable.

Table XL shows that, except in graded rural schools, the difference between boys and girls was significant at the .01 level throughout, including the total sample. It also indicates that, with the exception of town and graded rural, the differences between schools was significant throughout.

X. DIAGRAMS

A very large percentage (20%) of the pupils were unable to interpret diagrams well enough to solve problems. Statistics on errors in problems based on diagrams are given in Tables XLI and XLII.

TABLE XLI
ERRORS IN INTERPRETING DIAGRAMS

Sample	A.S.	E.D.	Per cent E.D.
Urban - Boys	261	35	13.41
Girls	376	78	20.47
Combined	637	113	17.74
Town - Boys	243	59	24.28
Girls	213	36	16.90
Combined	456	95	20.83
G.R. - Boys	240	53	22.08
Girls	192	38	19.79
Combined	432	91	21.06
U.R. - Boys	187	32	17.11
Girls	198	52	26.26
Combined	385	84	21.82
Total - Boys	931	179	19.23
Sample Girls	979	204	20.84
Combined	1910	383	20.05

Legend

A.S. attempted solutions
E.D. errors in interpreting
diagrams

G.R. graded rural
U.R. ungraded rural

Table XLI reveals some interesting facts which the writer is unable to explain. In two of the samples, boys are

superior to girls by a considerable margin, while in the other two samples, the girls are superior by an almost equal margin. The result is a small difference favoring the boys in the total sample. The rank order from lowest to highest percentage of errors was urban, town, graded rural and ungraded rural. Table XLII gives the significance of the differences.

TABLE XLII

SIGNIFICANCE OF DIFFERENCES IN ERRORS
IN INTERPRETING DIAGRAM

Samples	D.	S.E.D.	C.R.	Sig.
BOYS - GIRLS				
Urban	- 7.06	1.33	5.31	.01
Town	7.38	1.90	3.88	.01
Graded Rural	2.29	2.02	1.13	---
Ungraded Rural	- 9.15	2.16	4.24	.01
Total Sample	- 1.61	.69	2.33	.05
BOYS AND GIRLS COMBINED				
Urban - Town	- 3.09	1.18	2.62	.01
Urban - G.R.	- 3.32	1.20	2.77	.01
Urban - U.R.	- 4.08	1.27	3.21	.01
Town - G.R.	- .23	1.41	.16	---
Town - U.R.	- .99	1.48	.67	---
G.R. - U.R.	- .76	1.50	.51	---

Legend

D. difference
C.R. critical ratio
G.R. graded rural
S.E.D. standard error of difference
Sig. significance
U.R. ungraded rural

The minus sign indicates a higher percentage of errors in the second variable.

It will be seen from Table XLIII that as far as sex differences were concerned, the results of questions based on diagrams were very irregular. In urban and ungraded rural schools, the boys were definitely superior to the girls at the .01 level of significance, while in town schools the boys were inferior. In graded rural schools, the girls' superiority was not statistically significant. In the total sample, the boys were significantly better than the girls at the .05 level.

The achievement of pupils in urban schools was significantly superior to that of the other three schools at the .01 level of confidence. Otherwise there was no significant difference among the schools.

XI. FORMULAS

The last classification of errors to be considered, and the most troublesome for the pupils, was the one where formulas were required for solution of the problems. More than one-third of the six hundred fifty-two attempted solutions to these questions were wrong, as Tables XLIII and XLIV illustrate.

TABLE XLIII
ERRORS IN USING FORMULAS

Sample	A.S.	E.F.	Per cent E.F.
Urban - Boys	87	27	31.03
Girls	126	49	38.89
Combined	213	76	35.68
Town - Boys	85	21	24.71
Girls	78	28	35.90
Combined	163	49	30.06
G.R. - Boys	81	29	35.80
Girls	67	30	44.78
Combined	148	59	39.87
U.R. - Boys	64	17	25.56
Girls	64	30	46.88
Combined	128	47	36.72
Total - Boys	317	94	29.65
Sample Girls	335	137	40.89
Combined	652	231	35.43

Legend

A.S. attempted solutions
E.F. errors in the use of
formulas

G.R. graded rural
U.R. ungraded rural

While the percentages are generally high, it is interesting to note that in using formulas girls invariably had higher percentages of errors than the boys. The rank order from lowest to highest percentage of errors was town, urban, ungraded rural, and graded rural.

TABLE XLIV

SIGNIFICANCE OF DIFFERENCES IN ERRORS IN USING FORMULAS

Samples	D.	S.E.D.	C.R.	Sig.
BOYS - GIRLS				
Urban	- 7.86	4.84	1.62	---
Town	-11.19	4.67	2.39	.05
Graded Rural	- 8.98	6.61	1.36	---
Ungraded Rural	-20.32	6.24	3.26	.01
Total Sample	-11.24	2.71	4.15	.01
BOYS AND GIRLS COMBINED				
Urban - Town	5.62	3.41	1.65	---
Urban - G.R.	- 4.19	4.05	1.03	---
Urban - U.R.	- 1.04	4.05	.26	---
Town - G.R.	- 9.81	3.93	2.49	.05
Town - U.R.	- 6.66	3.92	1.70	---
G.R. - U.R.	3.15	4.62	.68	---

Legend

D. difference
C.R. critical ratio
G.R. graded rural

S.E.D. standard error of difference
Sig. significance
U.R. ungraded rural

The minus sign indicates a higher percentage of errors in the second variable.

In spite of the substantial differences between the percentages of boys and girls, only in two groups were these differences significant, viz. in town pupils at the .05 level, and in ungraded rural pupils at the .01 level. In the whole sample, boys were superior to girls, significant at the .01 level. The only significant difference between schools was the superiority of town schools over graded rural schools at the .05 level.

XII. SUMMARY

This chapter has presented the differences in difficulties in problem solving between boys and girls and among the four types of schools. From the statistics we find that the percentage of errors varies greatly from one type of problem to another. Boys make fewer errors than do girls in computation, reading and vocabulary, fundamental processes, per cent, estimating answers, using diagrams and formulas, but make more mistakes than do girls in fractions and decimals and in denominate numbers. Urban pupils make fewer errors than those from other schools in almost every type of problem.

CHAPTER VII

CONCLUSIONS AND RECOMMENDATIONS

I. CONCLUSIONS

On the basis of evidence found in this investigation, the writer has reached a number of conclusions:

1. Alberta grade eight pupils do not achieve equally well in all types of problems, doing their best work in problems requiring little else than computational skill, and their poorest work in problems requiring knowledge of formulas for correct solutions. Achievement differs significantly with almost every type of problem.
2. Diagnosis of difficulties in problem solving indicates that grade eight pupils make many more errors of some types than of others. They do very well with fractions and decimals and fairly well in fundamental processes, denominate numbers, and computation. They make more errors in percentage problems, reading and vocabulary, and estimating answers, and fall down badly in using diagrams and formulas.
3. There is a considerable difference in the proficiency of pupils from different environments in solving various types of problems. With the exception of

ungraded rural pupils, who are consistently weaker than pupils from city, town and graded rural schools, the four classifications do not achieve in a fixed order of rank. Pupils from graded rural schools frequently exceed those from town schools in achievement, and occasionally lead all other groups. In other problems, town schools reach a higher achievement than any of the others, although urban schools are most often at the top.

4. There is a slight difference in achievement in problem solving between boys and girls in Alberta grade eight classes. Usually this difference favors the boys, but such superiority in the male is not consistent. In ungraded rural schools, girls frequently score better than boys. When the comparison is based on attempted solutions, the difference is most apparent. The reason for this seems to be that boys tend to omit a difficult problem, while girls will attempt a solution even when they are unable to get the right answer.

There may be various reasons for the differences noted above. It seems reasonable to assume that students solve meaningful problems with more facility than those which mean very little to them. Thus, a student who has had experience in following a road map would have an advantage in solving that

type of problem over one who has never read such a map. It is quite possible for a problem to be within the experience of a city pupil and at the same time be completely foreign to a pupil from the country, and vice versa.

Since teachers in ungraded rural schools have to divide their instruction time among several grades, it is to be expected that pupils attending such schools will fail to reach the level of achievement of those who receive full time instruction. The statistics of this investigation seem to confirm this hypothesis.

It seems probable, too, that many of our pupils are allowed to go through school without having their difficulties diagnosed so that individual help may be given. This would be true most often where a teacher's time is limited. If remedial work, based on careful diagnosis, were given whenever a weakness is discovered, achievement might be expected to improve.

As for sex differences, the reason for the slight superiority of the boys is possibly due to the fact that many of the problems are more closely related to a boy's experience rather than to a girl's. Few girls, for example, would be concerned with the amount of coal which may be stored in a bin of certain dimensions. In problems where experience is equalized, such as finding the cost of an article, the girls prove at least equal to boys in efficiency.

II. RECOMMENDATIONS

After reviewing the data of this study, the writer makes the following recommendations:

1. Teachers of arithmetic should strive to give their pupils insight into all phases of problem solving so that it will not be necessary for a student to rely on memory alone in attempting a solution. For example, the diagnosis of certain problems reveals that many pupils do not understand the algebra of formulas, but will attempt a solution by trying to recall a procedure which to them is meaningless.
2. Diagnostic testing on a classroom basis for purposes of finding pupils' weaknesses in problem solving should be frequent. Tests for this purpose, based on the Alberta program of studies, should be made available to our teachers, so that preventive and remedial teaching would help our students overcome their individual difficulties.
3. The present trend towards centralizing rural schools should be encouraged where conditions warrant it. Graded rural pupils generally achieve on a par with town pupils, and, in problem solving, are not significantly inferior to urban pupils. Classes from ungraded rural schools, on the other hand, fail to come up to the achievement of those from any of the other

schools. Since no teacher can hope to do the same work with each of several grades as another does with a single class, centralization would seem to be one solution to the problem of equalizing educational opportunities in Alberta.

4. Writers of arithmetic text books should strive to reach a balance in problems suited to the interests of boys and girls. While the difference in achievement between the sexes is not great, it is possible that present textbooks favor the boys. A study of this hypothesis may prove the writer to be wrong, but could lead to interesting and useful findings.

The writer feels that adopting the recommendations outlined above would help to equalize educational opportunities in Alberta and to improve the proficiency of our pupils in solving problems in arithmetic.

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APPENDIX

The problem solving part of the test consists of thirty-one questions based on problems as stated below. The numbering of the questions is a continuation of that used in Parts I and II. Four possible answers are given for each question. In twenty-one cases, one of the four answers merely indicates that none of the other three is correct.

Directions to the pupils are as follows:

"Read each problem carefully. Do your work on scratch paper. Compare your answer with those given on the answer sheet and mark the proper box, as you did in Part II.

"In some problems, you are asked to give only an approximate answer. For these particular problems, no N is given on the answer sheet, but you are to mark the box in front of the answer that is most nearly like your own."

The problems with possible answers are analyzed on the following pages.

"At the beginning of the year, there were 13 girls and 18 boys in the third grade, 15 girls and 12 boys in the fourth grade, 11 girls and 16 boys in the fifth grade, and 13 girls and 13 boys in the sixth grade of the Jackson School."

74. "How many girls were in the four grades?"

Answers: 41, 52, 111, N

41 indicates a reading deficiency, as the answer is arrived at by omitting the 11 girls in the fifth grade.

52 is the correct answer.

111 indicates lack of understanding processes, as all numbers have been added.

Since there is a correct answer, it is impossible to determine how a pupil arrived at the answer N.

75. "How many more boys than girls were there in all four grades?"

Answers: 108, 110, 112, N

The first three of these are approximations of the total number of pupils, and therefore indicate that students giving any of these have used the wrong process.

N is the correct answer.

76. "At the end of the year, there were 34 children in the fifth grade. How many more children were in the fifth grade at the end of the year than at the beginning?"

Answers: 6, 7, 8, N

6 indicates an error in computation, either in subtraction or addition.

7 is the correct answer.

8 indicates an error in reading, as the figures for the sixth grade have been used.

N is impossible to analyze.

77. "The absences in the fifth grade during one week were as follows: Monday 3, Tuesday 0, Wednesday 5, Thursday 2, Friday 5. What was the average number of absences for each day?"

Answers: 2, 4, 5, N

2 and 5 must be considered reading errors, as students giving these choices obviously do not understand the meaning of the term "average". These numbers have merely been chosen from the list of absences on individual days.

4 is an error in procedure, as the lack of absences on Tuesday has been ignored, and the average of the other four days has been brought to the nearest whole number.

N is the correct answer.

"On an automobile trip with his father, Tom kept a record of the speedometer readings as they drove along. At home it read 9209; at Salem the reading was 9217; at Vale City, 9291 miles; and at Greenville, 9356 miles."

78. "How far was it from Salem to Vale City?"

Answers: 74, 84, 147, N

74 is the correct answer.

84 is an error in computation, as it indicates incorrect borrowing.

147 indicates a reading deficiency, as the first reading has been subtracted from the last.

N is impossible to analyze.

79. "If it took 3 hours to make the trip from home to Greenville, how many miles per hour did they travel?"

Answers: 47, 49, 52, N

47 is an error in computation.

49 is the correct answer.

52 is a reading error, as the last digit "9" in 9209 has been read as an "0" in computing the total distance.

N is impossible to analyze.

80. "Before he started, Tom's father bought 8 gallons of gasoline at 17¢ per gallon and a quart of oil at 36¢ per quart. What was his bill?"

Answers: \$1.36, \$1.62, \$1.72, N

\$1.36 is an error in procedure, as the cost of the oil has not been added to the cost of the gasoline.

\$1.62 is an error in computation, as the ten from the units column has not been carried to the tens column.

\$1.72 is the correct answer.

N is impossible to analyze.

"The Girls' Club sold Christmas cards at \$1.00 per box. The cards cost them 60¢ per box."

81. "How much profit did they make on each box of cards they sold?"

Answers: \$.40, \$4.00, \$6.00, N

\$.40 is the correct answer.

\$4.00 is an error in decimals.

\$6.00 is an error in procedure.

N is impossible to analyze.

82. "Their profit was what per cent of the selling price?"

Answers: 40%, 50%, 60%, N

40% is the correct answer.

50% indicates lack of knowledge of the use of per cent in finding profit.

60% is a reading difficulty, as the cost rather than the profit has been used in computing the percentage.

N is impossible to analyze.

83. "How much would it cost to send a letter weighing

$2\frac{1}{2}$ ounces to Australia if postal rates are 5¢ for the first ounce and 3¢ for each additional ounce or fraction of an ounce?"

Answers: $7\frac{1}{2}$ ¢, 11¢, $12\frac{1}{2}$ ¢, N

$7\frac{1}{2}$ ¢ indicates inability to use denominate numbers, as obviously $2\frac{1}{2}$ ounces have been added to 5¢.

11¢ is the correct answer.

$12\frac{1}{2}$ ¢ indicates a reading deficiency as a part of the essential information has been ignored. $2\frac{1}{2}$ ounces have obviously been multiplied by 5¢.

N is impossible to analyze.

84. "How many tons of coal can be stored in a bin 4 feet wide, 10 feet long, and 3 feet deep? (Coal weighs about 50 pounds per cu.ft.)"

Answers: 3, 60, 120, N

3 is the correct answer.

60 indicates a reading or vocabulary deficiency, as a ton has been confused with a hundredweight.

120 indicates an error in procedure, as it shows only the volume of the bin in cubic feet.

N is impossible to analyze.

85. "The seventh grade planned to take a trip to an Indian reservation. The teacher said, 'Mr. Brown is taking 5 of the children in his car, and I can take 3. That means we have rides for one-fourth of the class.' How many children were in the seventh grade?"

Answers: 12, 20, 32, N

12 is a reading deficiency, as 3 has been multiplied by 4, while the 5 has been ignored.

20 is also a reading error, as this time the 3 has been omitted.

32 is the correct answer.

N is impossible to analyze.

86. "Ship A is rated as of 12480 tons. If ship B is about one-fourth as large, what is its tonnage? (Note that in this problem no exact relationship is stated. Therefore, your answer will be only an approximation.)"

Answers: 2,500 tons, 3,000 tons, 6,000 tons, 50,000 tons
2,500 tons shows lack of understanding of approximations.
3,000 tons is the correct answer.

6,000 tons indicates a fraction difficulty, as $\frac{1}{2}$ has been used in place of $\frac{1}{4}$.

50,000 tons is an error in procedure, as the tonnage of ship A has been divided by $\frac{1}{4}$ instead of being multiplied.

87. "A certain airplane has a top speed of 435 miles per hour. The airplane is how many times as fast as an automobile which has a top speed of 90 miles per hour? (Only an approximate answer is required.)"

Answers: 3 times, 4 times, 5 times, 6 times

3 times indicates a lack of ability to estimate an answer.

4 times is an approximation error, as obviously the remainder has been ignored in the division.

5 times is the correct answer.

6 times indicates inability to estimate.

88. "If a man plants 105 of his 160 acres in corn, about what part of his farm does he plant in corn? (Only an approximate answer is required.)"

Answers: 105 per cent, one-half, two-thirds, three-fourths
105 per cent shows inability to use per cent.

One-half indicates inability to use fractions.

Two-thirds is the correct answer.

Three-fourths indicates inability to estimate an answer.

89. "A dress in a store window has these two prices marked on it: 'Was \$12.98 - Now \$10.25.' The amount that the dress was reduced is what part of the original price? (Only an approximate answer is required.)"

Answers: one-third, one-fifth, one-tenth, three-fourths

One-third indicates inability to estimate answers.

One-fifth is correct.

One-tenth indicates lack of understanding of fractions.

Three-fourths is an error in procedure, as it indicates division only with subtraction omitted.

90. "John is waiting for a train that is scheduled to arrive at 9:35 A.M. but has been marked 8 hours late. John looks at his watch and sees that it is 9:00 A.M. About how much longer must he wait for the train? (Only an approximate answer is required.)"

Answers: 6 hours, $7\frac{1}{2}$ hours, $8\frac{1}{2}$ hours, 9 hours

(Analysis on Page 103)

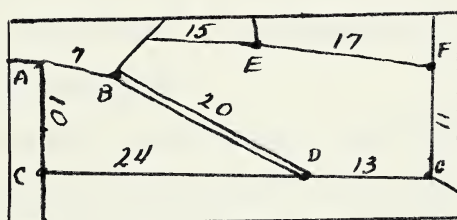
6 hours shows complete inability to estimate time.

$7\frac{1}{2}$ hours indicates a reading difficulty, as the wrong figures have been used.

$8\frac{1}{2}$ hours is the correct answer.

9 hours indicates inability to estimate time.

DIAGRAM



"This is a section of a road map. The numbers between points indicate the number of miles between those points. The solid line indicates paved road. The double line indicates gravel road."

91. "What is the shortest road distance from A to G?"

Answers: 40 miles, 47 miles, 50 miles, N

40 miles is the correct answer.

47 miles indicates inability to interpret a diagram, as vertical and horizontal lines only have been followed.

50 miles is an error in computation as the distances have been incorrectly added.

N is impossible to analyze.

92. "In going from D to A, how many miles farther is it to go the all paved road than to go over part that is gravel?"

Answers: 3 miles, 6 miles, 7 miles, 10 miles

3 miles indicates inability to interpret the diagram, as it merely shows the difference in length between AB and AC.

6 miles is an error in computation.

7 miles is correct.

10 miles shows inability to use the diagram. It is the length of the vertical line only, and indicates that AD and CD are considered to be of equal length.

93. "About what per cent of the most direct road from B to G is paved? (Only an approximate answer is required.)"

Answers: 15%, 40%, 55%, 75%

15% indicates misunderstanding of per cent, as the distance 13 miles has merely been approximated and called per cent.

40% is correct.

55% indicates inability to use the diagram, as it is the result of using the wrong figures.

75% is a reading difficulty, as it is a rough approximation of the per cent of paved road over gravel road.

94. "If the cost of building a paved road is \$55,000 per mile, what was the total cost of the road from C to D?"

Answers: \$132,000, \$1,300,000, \$1,320,000, N

\$132,000 is an error in reading, as 24 miles has been multiplied by \$5,500 rather than by \$55,000.

\$1,300,000 is an approximation when an accurate answer is required.

\$1,320,000 is correct.

N is impossible to analyze.

95. "If the cost of building a gravel road is only \$6,000 per mile, how many miles of gravel road can be built for the same amount of money that one mile of paved road costs (\$55,000)?"

Answers: 7 miles, 20 miles, 91 miles, N

7 miles is a computation error indicating incorrect division.

20 miles is a reading deficiency as the figure has merely been taken from the stretch of gravel road on the map.

91 miles is an error in decimals, as the decimal point has been omitted.

N is the correct answer.

96. "On an auto trip, Mr. Brown goes from C to F by way of G. He returns by way of A. How many miles did he drive on the trip?"

Answers: 96, 97, 99, N

96 indicates an error in computation.

97 is the correct answer.

99 indicates an error in computation.

N is impossible to analyze.

97. "What is the approximate area in square miles of the region enclosed by the road from A to C to D and then back to A by way of B?"

Answers: 51 sq.mi., 120 sq.mi., 240 sq.mi., 480 sq.mi.

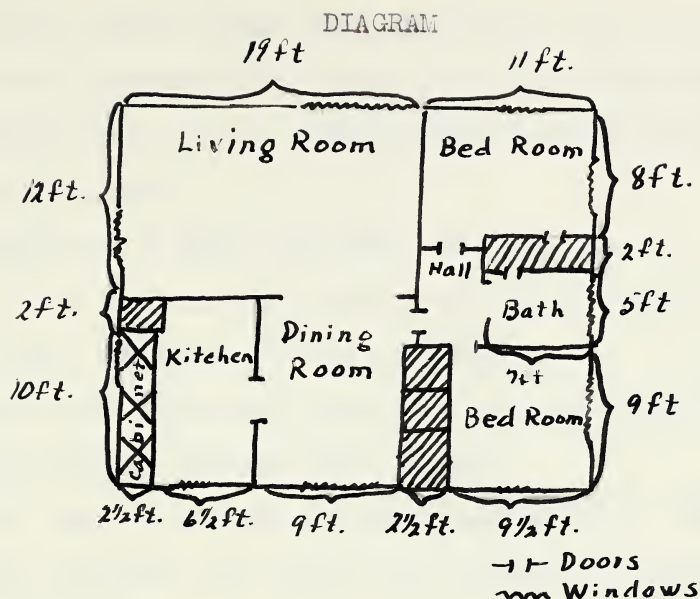
51 sq.mi. indicates inability to use a formula, since the perimeter has been found rather than the area.

120 sq.mi. is the correct answer.

240 sq.mi. indicates lack of knowledge of formulas,

as $a = lw$ has been used in place of $a = \frac{1}{2}bh$.

480 sq.mi. is an error in procedure as bh has been divided by $\frac{1}{2}$ when it should have been multiplied.



"This is a simplified floor plan of a house. (You may consider the dimensions given as the inside dimensions of the room, and you need pay no attention to the thickness of walls and partitions.) The shaded areas represent space used for closets. Problems 98 to 104 are based on this diagram."

98. "What is the total area of this floor plan?"

Answers: 108 sq.ft., 680 sq.ft., 720 sq.ft., N

108 sq.ft. shows inability to use a formula, as the perimeter has been found instead of the area

680 sq.ft. indicates inability to interpret the diagram, as closets have been subtracted from the total area.

720 sq.ft. is the correct answer.

N is impossible to analyze.

99. "The kitchen floor and cabinet top are to be covered with linoleum which comes only in 6-foot widths. How many feet of this 6-foot width material should be purchased?"

Answers: 9 feet, 108 feet, 20 feet, N

9 feet is a reading error, as the pupil has merely taken the width of the kitchen.

108 feet indicates incorrect procedure, as the area is that of kitchen plus closet.

20 feet is a reading error, as the 10 ft. length of the cabinet has merely been doubled to include the kitchen.

N is the correct answer.

100. "The floor carpeting for the living room of this house costs \$5.10 a square yard. What will be the cost of this carpeting?"

Answers: \$129.20, \$387.60, \$1162.80, N

\$129.20 is the correct answer.

\$387.60 shows inability to use denominate numbers, as 3 square feet have been treated as 1 square yard.

\$1162.80 is an error in reading. Square feet have been used as square yards.

N is impossible to analyze.

101. "About what fraction of the total area is used in closets? (Only an approximate answer required.)"

Answers: $1/18$, $1/10$, $1/8$, $1/5$

$1/18$ is the correct answer.

$1/10$ indicates inability to interpret the diagram.

It is based on the kitchen only.

$1/8$ shows inability to use the diagram. This answer is based only on rooms containing cupboards.

$1/5$ also indicates inability to use the diagram. It is based on the bed room area only.

102. "The builder of this house thought that the estimate on the cost of doors was too high. The contractor pointed out that outside doors were \$15 each, standard interior doors were \$4.50 each, and closet doors were \$3.00. The estimate for doors was \$70.00. How much too high was this estimate?"

Answers: None, \$1.50, \$.50, N

None is an error in computation, as there was a slight discrepancy between the estimate and the actual cost.

\$1.50 is also an error in computation.

\$.50 is an error in reading, as the estimate was too low by this amount.

N is the correct answer.

103. "If the large living room and dining room windows together cost \$85.00 and the other windows cost \$25.00 per unit, what was the cost of windows in this house?"
Answers: \$185, \$260, \$285, N

\$185 is an error in reading or vocabulary, since a room has been treated as a unit.

\$260 indicates misinterpretation of the diagram, as a small window has been omitted.

\$285 is the correct answer.

N is impossible to analyze.

104. "The loan on this house is \$5,000, on which the owner pays \$30.00 per month. If the rate of interest is 5%, what is the approximate amount of the principal that is paid the first month? (Only an approximate answer is required.)"

Answers: \$9, \$15, \$18, \$22

\$9 is the correct answer.

\$15 indicates inability to use per cent, as it is 50 per cent of the payment.

\$18 indicates incorrect procedure, as it is 5 per cent of the payments for a year.

\$22 is an error in reading or vocabulary, as interest has been confused with principal.

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